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FAUNA ANTIQUA SIVALENSIS,

BEING THE

FOSSIL ZOOLOGY OF THE SEWALIK HILLS, IN THE NORTH OF INDIA.

BY

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FAUNA ANTIQUA SIVALENSIS.

THE plan which we have laid down for our guidance in the conduct of this work, is in the first place, to determine the remains of the extinct genera and species, and, on the conclusion of the systematic and descriptive details, to investigate the general results to which they lead. The advantages of this method are so obvious that it is unnecessary to insist upon them: for general conclusions in science are of little value, if the facts upon which they are founded be not in the first instance rigidly and accurately ascertained. The order to be observed in describing the different families, will depend more on the state of preparation and convenience of the materials, than upon any strict principle of zoological arrangement. This, which might be deemed objectionable in a general systematic work, is of little consequence in the case of a particular Fossil Fauna, provided that the forms in each family and genus are taken in sequence. The great palæontological work of Cuvier, opens with the Pachydermata, the Proboscidea being the first in the order of description. Following our illustrious guide in extinct zoology, we shall commence with the Elephant group, in which is most signally displayed the numerical richness of forms which characterizes the Fossil Fauna of India.

I.—PACHYDERMATA.

CHAP. I. PROBOSCIDEA.—ELEPHANT AND MASTODON.

§ 1.—GENERAL REMARKS.

THE fossil remains of the Proboscidean Pachydermata have in all ages attracted more attention, both from the learned and from the unlearned, than perhaps those of any other family of extinct animals. Until a comparatively late period in Europe, and at the present time in all countries where the light of anatomy cannot be brought to bear in solving the mystery of their indications, the enormous bones of this tribe, when disinterred from the earth, have been regarded as demonstrative evidence of the former existence of Titans, Giants, and other fabulous beings handed down to us in the records of superstition and mythology. Like the Greeks and Romans of old, the people of India even now, usually refer such remains to the *Rakshas* or Titans, who hold so prominent a place in the ancient writings of that country. The severe investigations of modern science, have expelled these fictions from the belief of civilized mankind; and reconstructed the true forms of the animals which appear in many instances to have given rise to them. Palæontology made, as it were, its first great advance in the exact determination by Cuvier of the Mammoth of Siberia, and the Mastodon of North America. Since that time several new forms have been discovered, and most of the great points connected with the structure of the Proboscidea, fossil and recent, have been ascertained. But, notwithstanding the vast amount of observation on the subject during late years, a great difference of opinion has prevailed among Comparative Anatomists and palæontologists, down even to the period when we now write, in regard to the degree of affinity and generic relations of the different species of Mastodon and Elephant. The majority of late authorities, including Cuvier and Owen, have regarded them as constituting two distinct and well marked, although closely-allied genera; others have gone the length of breaking up Mastodon into two genera; while M. de Blainville has reverted to the opinion of some of the earlier observers, that the so-called Mastodons and Elephants are but modifications of one common type, differing so little from each other that all the species may, with propriety, be included within the limits of a single genus. A still greater, and vastly more important difference of opinion has prevailed, regarding the number and characters of the species: for, while the conflicting views respecting the generic distinctions concern little more than the principles of systematic classification, the accurate determination of the fossil species affects the value of facts, which implicate the accuracy of some of the most weighty arguments in the geology of the later tertiary strata, more especially such as relate to the changes of climate which are supposed to have accompanied their deposition, and the extension of the species through a wide range of time and space. Cuvier considered all the Elephant remains which have been found in Europe, the north of Asia, and America, whether occurring in the superficial drift of Siberia, or in the tertiary beds of the Val d'Arno, to belong strictly to a single species, *Elephas primigenius*. Professor Owen, with all the lights, and wielding every arm of an advanced science, holds the same opinion. M. de Blainville does not think that there are sufficient characters, even for separating the Mammoth from the existing Indian Elephant, both of which he appears to regard as varieties of the same species.[1] On the other hand Nesti, after a careful study of the Elephant remains of Italy, during a period of nearly twenty years, upon an ample collection of the best materials in the form of crania, jaws, and teeth, insists upon the specific distinctness of the Tuscan fossil Elephant, *E. meridionalis*, from the true Mammoth of Siberia. Other palæontologists have gone so far as to construct ten species out of the single species of Cuvier, founding the distinctive characters upon the differences presented by the molar teeth. A like range of conflicting opinions has prevailed in regard to the Mastodons. Cuvier, Owen, and de Blainville, concur in restricting the narrow-toothed Mastodons of Europe to a single species, the geographical range of which Cuvier extended even to South America: while Croizet and Jobert, Kaup, Von Meyer and others, divide them into two, *M. longirostris*, and *M. angustidens*. No less than two genera, and at least ten nominal species have been founded upon teeth which Owen, de Blainville, and most other authorities, attribute merely to different ages and sexes of a single species, the *M. Ohioticus* of North America. In short, the ascertained fossil species,—exclusive of those of India—according to some, are limited to one Elephant, and four or five Mastodons; while others would raise the number of the former to ten, and of the latter to upwards of twenty.

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[1] De Blainville, Ostéographie; Elephants, p. 222.

This great diversity of opinion, almost unequalled in regard to any other section of mammalian palæontology, has in a great measure arisen from the isolated and often defective nature of the materials relating to this tribe, as they ordinarily come before the palæontologist. From the peculiar mode of succession of the molar teeth, which yield the principal distinctive characters in Mastodon and Elephant, by repeated renewals from back to front, at different stages of the animal's growth, as the worn and exhausted grinders drop out, a limited number only of the whole series can be met with in any one fossil specimen, even under the most favourable conditions. It is this peculiarity which has so long retarded the attainment of an accurate knowledge of the dentition of the living species. The difficulty applies with double weight to the fossil species,[1] for the teeth are rarely met with in connexion with perfect crania and jaws: they most frequently occur detached, or connected with mutilated fragments. It is only, therefore, from the comparison of an extensive series of specimens, embracing every period of life and the range of individual and sexual varieties through which the species runs, that any safe conclusions can be drawn regarding the distinctive characters of any one form. In consequence, although palæontologists are agreed on the great points relating to the construction of the head, trunk, and extremities, hardly any two concur respecting the number, form, and succession of the teeth in the different species of Mastodon and Elephant.

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[1] In illustration, it may be mentioned, that Eichwald (Nova Act. Acad. Nat. Curios. 1834, vol. xvii. p. 735, tab. liii. fig. 2), in a memoir descriptive of fossil remains of Elephas, Mastodon, and Dinotherium, &c., found in Poland, figures and describes what appears to be a fragment of the symphysis of the *lower jaw* of *Dinotherium giganteum*, as a portion of the *upper jaw* of a new species of Mastodon, which he names *Mastodon Podolicus*. Other equally remarkable cases of the same kind might be adduced, so unsafe is it to draw conclusions regarding the fossil Proboscidea from imperfect materials.

The surprising number of forms belonging to this family, embraced in the Fossil Fauna of India, and the immense abundance in which their remains have been met with, have placed us perhaps, with respect to the quantity and perfect condition of the materials, in more favourable circumstances for the determination of the Sewalik species, than has ordinarily happened to the palæontologist in the case of most of the other fossil Proboscidea. Of five of the species to be described in the sequel, we possess nearly perfect crania of each, and, in most of the instances, crania with teeth of all ages, from the very young up to the adult animal, in addition to a vast collection of the detached teeth and lower jaws, so as to furnish us with the whole of the essential evidence requisite for the specific determination of each of these forms. The distinctive characters are so broadly marked, that there is hardly room for a doubt being entertained in regard to them. In the course of the investigation we have been led to examine the conclusions which have been arrived at by writers who have preceded us upon this family. The Indian species, and those previously described, fossil and recent, have mutually reflected light on each other, and ranged themselves into natural and allied groups. Instead, therefore, of restricting ourselves merely to a description of the Sewalik fossil forms, we shall endeavour, in what follows, to trace the affinities, and institute an arrangement of all the well-determined species in the family.

The results to which we have been conducted, lead us to differ on certain points from the opinions most commonly entertained at the present day; for while, on the one hand, it would appear that the fossil species of both Elephant and Mastodon have been unnecessarily multiplied by authors both in Europe and America, on the other, we are compelled to think that Cuvier, and others, have run into the opposite extreme of caution, and in more than one instance included distinct forms under the same nominal species. Further, in regard to the views which have been at different times advanced respecting the differential characters of Elephant and Mastodon, in the succession and development of the series of molar teeth, our conclusions are, in some measure, at variance with those of most other palæontologists who have preceded us upon this family.

Before entering upon the description of the species, we shall examine, at some length, the general characters presented by the teeth; but in order to comprehend the present state of knowledge on this branch of the subject, it will in the first instance be necessary to pass briefly under review the leading opinions which have been entertained by palæontologists regarding the relations of Mastodon and Elephant to each other, and to notice the successive steps in the discovery of new forms, which have led to the modifications of these opinions.

It is beside our object to give anything like a historical account of the labours of the earlier writers. Those who are desirous of the information, will find it detailed in the great work of Cuvier, down to the period at which he wrote: and for subsequent opinions, they may consult the 'Ostéographie' of de Blainville, now in course of publication, and the writings of Professor Owen, Bronn, von Meyer, Kaup, and other palæontological authors.

Notwithstanding the earlier contributions of Daubenton, Pallas, Merck, and the elder Camper, hardly anything was known regarding the succession of the teeth in the Elephant, except that they are repeated oftener than once during life, by protrusion in the jaws from behind forward, till the appearance of the memoir by Corse,[1] in the Philosophical Transactions of 1799. This excellent and careful observer had resided many years in India, in charge of a Government stud of Elephants in Bengal. By captures of herds of the wild animal he had an opportunity of watching the successive fall and renewal of the teeth, from the youngest age up to the adult, the periods of which he carefully recorded; and casualties supplied him with a series of upwards of thirty crania of all ages, upon which he studied the form, size, and the number of plates which enter into the composition of the grinders at different stages of the animal's life. The observations embodied in this memoir are the most valuable which have been made on the teeth of either of the living species. Corse first showed that the Indian Elephant has 'milk' tusks (incisors) which cut the gum when the calf is about six months old, but are extremely caducous, as they drop out between the first and second year. He detected the position of the capsule of the permanent tusks, which protrude about two months after the milk incisors are shed, and go on increasing in size during the rest of the Elephant's life. He has described the variations in size, form, and direction which the tusks present in the different sexes and castes of the Indian species, the general character of which castes he has accurately recorded; but the most valuable part of his observations is comprised in what relates to the molar teeth. He showed that they are reproduced several times during life, and that the number of plates entering into the composition of each molar goes on increasing as the teeth are successively renewed. This succession he has carefully traced up to the fourth grinder; the first cuts the gum eight or ten days after birth, is well out at six weeks, and is composed of four plates; the second is completely in use at two years, and consists of eight or nine plates; the third serves the period between the second and sixth year, and has twelve or thirteen plates; the fourth is in use between the sixth and tenth year, and consists, according to Corse, of about fifteen plates. Puzzled, probably, by the irregularity in the number of plates and the size of the rest of the molars in different individuals, this faithful observer stops short at the point where his observations ceased to be conclusive, and does not attempt to define the number of plates in those which follow after the fourth. He states, generally, that the plates go on increasing successively up to the 'seventh or eighth set,' when each grinder consists of twenty-two or twenty-three plates being the greatest number which he had observed.[1] These observations were of especial value in furnishing a standard of comparison for the teeth of the fossil species; and by establishing the existence of milk incisors, they proved that part at least of the dental system of the Elephant agreed with that of the ordinary Pachydermata. But Corse was at fault in the conjecture that eight molar teeth are successively developed in an antero-posterior series in this animal; for if this were the case, the Elephant would form an exception to a general law in the Pachydermata and allied orders, among which the normal number of milk molars does not exceed four, that of the true molars being invariably three.

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[1] Corse, Phil. Trans. 1799, vol. 89, p. 205.

Notwithstanding this objection, Corse's numerical statement was adopted by Cuvier and by all other authors prior to 1844, when it was, for the first time, challenged by M. de Blainville in the part of his 'Ostéographie' devoted to the Elephants. Bronn,[2] in his 'Lethæa,' gives eight molars on each side of both jaws to the genus Elephas; and Dr. Grant,[3] in his memoir upon the Proboscidea, puts forward different dental formulæ in the molars, as points of generic distinction between Elephant and Mastodon, attributing eight molars in each side to the former, and only six to the latter.

Cuvier, except in what regards his hypothetical explanation of the formation of the dental tissues, has described with admirable clearness, and in great detail, the structure and mode of growth of the teeth in the Elephant. But he had assuredly arrived at no accurate idea of the true division of the molar series into milk and permanent grinders. He makes no attempt to show where the deciduous series terminates and the true molars begin, although so particular upon this point in his descriptions of the dental system in the ordinary Pachydermata and Ruminantia. In fact, the term 'dent de lait' is but rarely applied in his Elephant descriptions; and in these instances, it has evidently reference more to the immature age of the animal, than in the ordinary sense of a deciduous tooth which is expelled by a vertical successor. Having adopted the excessive numerical formula of Corse, this great anatomist was led to believe that the successional premolars, instead of being suppressed, are developed behind the milk teeth. The language in which this remarkable opinion is expressed is clear and explicit:—" L'on pourroit dire que les dents de remplacement de l'Eléphant viennent derrière ses dents de lait, au lieu de venir dessus ou dessous, comme dans les autres animaux."[1]

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[1] Corse, *loc. cit.* p. 224.

[2] Bronn, Lethæa Geognostica, 1838, p. 1240.

[3] Grant, Geolog. Proceedings, 1842, vol. iii. p. 771.

The discovery of the entire set of molars in *Mastodon Ohioticus* by Dr. Hays,[2] in 1834, and in *M. longirostris*, by Dr. Kaup,[3] in 1835, had clearly established that the antero-posterior series in these species does not exceed six, and paved the way for an accurate knowledge of the dentition of the Elephant, when M. de Blainville published, in 1844, the osteographical memoir upon this genus, contained in his great work. This distinguished Anatomist, in his remarks upon the dentition of the Dugongs, first states that the Elephants (in which he includes the Mastodons) have neither milk teeth nor vertical successional teeth.[4] His words are—" Ainsi l'on peut dire que chez les Dugongs et chez les autres Lamantins, ainsi que chez les Eléphants, il n'y a ni dents de lait ni dents de remplacement, comme chez la plupart des autres mammifères; celles-ci poussant, pour ainsi dire, celles-là de bas en haut, et formant ainsi deux rangées superposées; mais que toutes les dents que doit avoir l'animal dans le cours de sa vie entière forment une seule ligne, un seul rang, un sort de boyau cylindrique, qui se développe d arrière en avant dans le canal dentaire, dont l'enorme diamètre est en partie dû à cette particularité. C'est quelque chose de semblable à ce qui existe dans les Eléphants." This statement is subsequently modified in the portion of the work devoted to the Elephants. M. de Blainville there prefers a claim to having first indicated the normal number, the mode of succession, and the true signification of the molar teeth in this genus.[5] He admits, on the evidence of Corse, milk and permanent incisors, but sees no occasion to apply a similar division of 'milk' and 'permanent' to the molar series. He follows their succession from first to last, and vindicates the first part of his claim, by showing that in the existing species, and probably in the Mammoth, the number of developed grinders is neither more nor less than six. But in regard to their signification, viewed as a series, we cannot, with every respect for this eminent Anatomist, admit that he has been equally successful. He divides the six molars into three sets, each consisting of two teeth ; the first includes the two anterior molars, which are characterized by being worn out in the part of the jaw where they first protrude ; the second set is characterized by being formed in the posterior part of the jaw, and at last pushed out in front ; and the third set, formed behind like the two preceding teeth, is characterized chiefly by serving the adult stage of the animal's life, and by the greater space which the teeth have to traverse in progressing forwards. This, however, is at best but an ætal division, and cannot be received as a philosophical interpretation of the theoretical signification of the molar series : for the second of these sets groups together the last milk and the first permanent molar. Further, M. de Blainville expresses, by a numerical formula,[1] his view of the dental system of the Elephant, which, if interpreted according to the exposition of his peculiar method of symbols, laid down in the first part of the Ostéographie, would imply that the Elephant has three premolars and three back molars, the milk series being suppressed : whereas, in the three species of which the dentition is known, it is in reality, the three milk molars that are invariably developed, while the three premolars are constantly suppressed.

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[1] Cuvier, Oss. Fossil. tom. i. p. 39, 4to edit. 1821.

[2] Hays, Amer. Phil. Trans. vol. iv. p. 320, 1834.

[3] Kaup, Oss. Fossil. pt. iv. p. 65-89, 1835.

[4] De Blainville, Ostéographie, 'Manatus,' p. 75.

[5] *Loc. cit.* p. 58. " Aussi dans aucune ouvrage le nombre normal, le mode de succession des dents molaires de l'Eléphant, et leur signification réelle, n'ont pas été deter-

Professor Owen, down to the close of 1844, appears to have held with Cuvier the opinion that the developed molars in the

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minès, ce que nous croyons pouvoir faire aujourd'hui d'une manière positive, en nous aidant, il est vrai, des dents fossiles que possèdent nos collections en plus grand nombre peut-être que des dents récentes."

[1] *Loc. cit.* p. 75. The formula given is $\frac{1}{0} + \frac{0}{0} + \frac{3}{3} + \frac{1}{1} + \frac{2}{2}$. The signification of these figures, indicated in the opening memoir "Sur les Mammifères en general," p. 34, is $\frac{1}{1}$ in. + $\frac{0}{0}$ can. + $\frac{3}{3}$ avant mol. + $\frac{1}{1}$ princip. + $\frac{2}{2}$ arrière mol.

Asiatic Elephant amounted to seven or eight. This number, adopted on the authority of Corse, is stated in his 'British Fossil Mammalia.'[1] But it was not likely that the true numerical formula would escape the sagacity of this eminent Comparative Anatomist when directed to the teeth of the Elephant in connection with those of the ordinary Pachydermata. Accordingly, in the last part of his Odontography, while he agrees with M. de Blainville in attributing six molars on each side of the jaws to this genus,[2] he has made a considerable step in advance of the latter Anatomist in regard to their signification. The occurrence of a vertical successional premolar in the upper jaw of one or more species of Mastodon had previously established that the two anterior grinding teeth in that genus are displaced, like the milk teeth in the ordinary Pachydermata, by a vertical successor. Professor Owen follows up this indication to its legitimate conclusion, and infers that the third molar in the series of antero-posterior succession in the Mastodon, is the last milk molar, the vertical successional tooth by which it ought, normally, to be pushed out, usually remaining undeveloped. He then extends this view to the dentition of the Elephant, and states that 'it is probable that the three preceding teeth' (namely the three first developed molars) 'are analogous to the true deciduous molars of the ordinary Pachyderms.'[3] The correctness of this opinion is susceptible of demonstration by the dentition of an Indian fossil species which we have named *Elephas planifrons*, to be described in this work. The determination of the point was of great zoological interest, by explaining the apparent anomaly which had hitherto divided the teeth of the Elephant from those of the allied families in the order.

Next, in regard to the establishment of the species.—The fossil remains of the Mammoth had, during ages, attracted more or less attention in every country in Europe, having been found in England and in all parts of the Continent, from Italy to Siberia. But it was only towards the close of the last century that definite notions as to the species, were arrived at. Pallas, who had better opportunities for determining the point than any of his cotemporaries, upon the perfect remains so commonly met with in Russia, erroneously considered the fossil teeth to be identical with those of the Indian species. A great advance was made in the inquiry through the discovery, by Peter Camper, of the specific difference between the teeth of the Asiatic and African Elephants,[1] when Blumenbach and Cuvier almost simultaneously entered upon the investigation, and arrived at the same result, viz., that the Mammoth was an extinct form, differing from both of the existing species. Struck with the length of the cranium, and of the incisive sheaths in the Mammoth, as represented in the figures of Messerschmidt's specimen attached to Breyne's excellent remarks in the Philosophical Transactions,[2] and connecting these peculiarities with the great width of the crown, and the narrowness and number of the plates in the fossil grinders, Cuvier was conducted to his first happy conclusion. The probability of a similar difference characterizing the species in other fossil genera, flashed across his mind, and opened to him new views respecting the theory of the earth. Great and important were the results; and after they had been achieved, the illustrious Anatomist reverted, in terms of the liveliest acknowledgment, to the long neglected figures of Messerschmidt, which had helped him to the first idea.[3]

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[1] Owen, Brit. Foss. Mammal. part v. p. 225.

[2] *Idem*, Odontography, 1845, p. 626, and note p. 635.

[3] *Id. loc. cit.* p. 634.

After determining the specific independence of the Mammoth, the next point to ascertain was, whether the remains occurring in very different deposits, and in localities widely contrasted in climate and in geographical position, belonged to the same or to different species. Notwithstanding that the fossil teeth from the southern parts of Europe commonly presented wider and fewer plates, with thicker enamel, than those of the typical form of Mammoth found in Siberia, Cuvier attached minor importance to these differences, as the teeth agreed in certain other respects; and he ranged the whole under the single species of *Elephas primigenius*.

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[1] P. Camper, Déscript. Anatom. d'un Eléphant male, p. 16.

[2] Phil. Trans. vol. xl. 1738, p. 124.

[3] Cuvier, Oss. Fossil. tom. i. p. 178.

This opinion has been very generally adopted by subsequent authors, among others, by M. de Blainville, and by Professor Owen, who has entered at considerable length upon the question, in his 'British Fossil Mammalia,' and decided in favour of the specific unity of the European forms. But notwithstanding this array of authority, we cannot help thinking that Cuvier was premature in his conclusion, and that the identity of the forms has rather been assumed against the evidence, than proved by it. Had the differences in the teeth been less considerable than they are known to be, it would have been requisite to show that the crania at least agreed, before this identity could be considered to have been satisfactorily established. But there were not sufficient materials for making such a comparison when Cuvier wrote. The cranium of the Siberian Mammoth was known to him only through figures of five specimens, not one of which was drawn in any exact projection; and his acquaintance with the Italian fossil Elephant, exclusive of teeth, was limited, in regard to the head, to a single mutilated fragment, not extending above the orbits and maxillary bones. There is little doubt, also, that like other writers, he was partly swayed by the extraneous consideration of the geographic range of the two existing Elephants, the continents of Asia and Africa having each but a single species. We have the less hesitation in advancing these doubts, as conclusive proof will be adduced in the sequel that, in the similar instance of the *Mastodon angustidens*, Cuvier and others have included under that name two forms which are so distinct that, in our view, they do not even belong to the same section of the genus; while the Sewalik fossil remains show that there were formerly several species of Elephant at one time in the same Fauna in India.

Soon after the publication of Cuvier's Memoir, Nesti, in 1808, proposed an addition to the European fossil species, founded on remains from the Val d'Arno.[1] He put forward two new species: the first, resting on a lower jaw without teeth, was characterized by a peculiar spout-shaped prolongation of the symphysial apophysis; the second, which he named *E. mini-*

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[1] Nesti, Annale del Museo de Firenze, tom. i.

mus, also resting upon a lower jaw, was distinguished by its supposed small size, by the absence of the beak apophysis, and by the rhomboid section presented by the plates of the grinders. Cuvier refused to admit either of Nesti's species. The lower jaw of the first he pronounced to belong rather to *Mastodon angustidens* than to an Elephant; and the second to be nothing more than the lower jaw of a young individual.[1] Nesti, after a long silence, reverted to the subject in 1825, in a memoir which embodied the results of extensive observations carefully made during seventeen years.[2] He tacitly admits the justness of Cuvier's criticism in regard to the second species, by abandoning *E. minimus;* but in confirmation of his first species he adduces a great mass of evidence derived from numerous crania of all ages, from the fœtus up to the adult; and from lower jaws in the Florence and other Tuscan musea,—all of which, he affirms, show the peculiar beak elongation of the symphysis in connection with Elephant's teeth. The result of the whole was to remove every doubt or hesitation from his mind regarding the distinctness of the Tuscan species, for which he proposes the specific name of *E. meridionalis.*

The value of the evidence regarding this species will be more fully considered in the sequel. Nesti's opinion, however, has met with little favour among palæontologists. Croizet and Jobert have adopted it for some of the elephant remains found in Auvergne,[3] and the name finds a place in the enumeration of species given in von Meyer's 'Palæologica.'[4] But it is not admitted by Bronn,[5] de Blainville,[6] or Pictet;[7] and it would appear from certain passages in the 'British Fossil Mammalia,' that the great weight of Professor Owen's authority is against it.[8]

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[1] Cuvier, Oss. Fossiles, tom. i. p. 186.

[2] Nesti, Nuovo Giornale de Letterat. Pisa, 1825, tom. xi. p. 119.

[3] Croizet et Jobert, Oss. Foss. du Puy-de-Dôme, 1828, p. 123.

[4] Von Meyer, Palæologica, 1832, p. 69.

[5] Bronn, Lethæa Geognostica, 1838, p. 1245.

[6] De Blainville, Ostéographie; Elephants, p. 220.

[7] Pictet, Palæontologie, 1844, tom. i. p. 243.

[8] Owen, Brit. Foss. Mamm. p. 239.

In 1821 Dr. Goldfuss[1] described a fossil grinder found in a collection at Cologne, which resembles very much that of the African Elephant, in the characteristic peculiarities of the rhomboid form and reduced number of the grinding plates. He states that the specimen, although the precise locality was unknown, has the cement and ivory as much decomposed as in the fossil grinders from Siberia. In a second memoir[2] he figures and describes other teeth presenting the same characters, from the banks of the Rühr, in Westphalia, and concludes from them that the valley of the Rhine had formerly an Elephant, which was more closely allied to the African, than the Mammoth was to the existing Indian species. He proposed naming it provisionally *Elephas priscus*.

Cuvier threw very strong doubts upon the authenticity of these specimens as veritable fossils, in consequence of the ambiguous circumstances under which they were found. He considered them to be nothing more than disguised remains of African elephants of modern origin.[3] But according to Bronn, fossil teeth of the same description have since been found, under circumstances fully to be depended upon, throughout nearly the whole of Central Europe, from the Rhine to the heart of Russia.[4] Some of them have been described by Wagner;[5] and undoubted fossil teeth, presenting similar characters, have been met with in the 'brick earth' beds of the valley of the Thames, at a considerable depth below the surface. These will be noticed afterwards in connexion with the dental series of one of the Indian fossil species.

Fischer de Waldheim, in 1829, proposed the separation from the Mammoth of no less than five fossil species of Elephant, founded upon remains occurring in Russia. These he has severally named—*E. proboletes*, *E. campylotes*, *E. Kamenskii*, *E. Panicus*, and *E. pygmæus*.[6] Dr. Eichwald went still further, and added a sixth species, from Poland, under the name of *E. odontotyran-*

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[1] Goldfuss, Nov. Act. Acad. Leop. Carol. Natur. Curios. vol. x. p. 485.

[2] *Idem, loc. cit.* vol. xi. p. 485.

[3] Cuvier, Oss. Fossiles, tom. ii. (8vo edit.) p. 184.

[4] Bronn, Lethæa Geog., p. 1244.

[5] Wagner, Karsten's Archiv. xvi. p. 21.

[6] Fischer de Waldheim, Bullet. de la Soc. de Moscou, 1829, tom. i. p. 275; Mémoires de la Soc. de Moscou, tom. i. p. 285.

nus.[1] But the almost universal consent of palæontologists is against these so-called species; which are considered to be nothing more than varieties in the teeth, dependent upon age and sex in individuals of the Mammoth.

M. Morren, under the name of *Elephas macrorhynchus*, has lately proposed a new species for some of the fossil remains found in Belgium; but the grounds upon which it rests do not appear to be more valid than in the case of the Russian and Polish species.[2]

Mastodon.—In regard to Mastodon: the first determined species of this genus was the *M. Ohioticus*[3] of North America. The abundant remains found nearly all over the temperate parts of the United States had, as in the instance of the Mammoth of Europe, attracted the notice of observant travellers to this great extinct animal, upwards of a century ago. But, till the time of Daubenton, hardly any progress had been made towards a definite idea of its nature. This celebrated naturalist, in 1762, ascertained the close resemblance of the femur and tusks to those of the Elephant: but the molars appeared to him to present a nearer approach to the teeth of the Hippopotamus, and he was puzzled whether to ascribe the fossils to one or to two distinct animals.[4] Buffon participated in these doubts, but inferred that a part of the remains indicated the former existence of a terrestrial animal which had become extinct, larger than the Elephant.[5] Peter Collinson, in the *Philo-*

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[1] Eichwald, Nova Acta Acad. Cæs. Leop. Car. Natur. Curios. 1834, vol. xvii. p. 723, tab. 63, figs. 1 and 2.

[2] Morren, Bulletin de la Soc. Géol. de France, tom. ii. p. 231.

[3] As in the case of the Mammoth (*E. primigenius*, Blum.) the specific name given by Blumenbach to the North American Mastodon, *M. Ohioticus* is here adopted instead either of *M. giganteum* or *M. maximus*, the names applied by Cuvier at different times. Blumenbach, in his 'Handbuch der Naturgeschichte,' had characterized the extinct animal by the form of the teeth, and called it *Mammut Ohioticum*, as a species of a peculiar genus, before the appearance of Cuvier's memoir (Annal. du Mus. tom. vi. p. 260, 1805), in which the designation of *M. giganteum* is first applied. This latter was abandoned (Oss. Foss. 4to edit. of 1824), for *M. maximus*. If the law of priority left a choice, *M. Ohioticus* would still be preferable to either of the names given by Cuvier, as the species is by no means the giant of the family.

[4] Daubenton, Actes de l'Académie des Sciences, 1762; and Histoire Natur. de Buffon, tom. xi.

[5] Buffon, Histoire Natur. tom. xi. p. 86.

sophical Transactions for 1768, gave some good figures of the back grinders, and shrewdly observed that the form of their crown was adapted for crushing boughs, twigs, and leaves, betokening the animal to have been of herbivorous habits.[1] William Hunter, struck with the great contrast between the salient enamel ridges of these teeth and the narrow plated flat surface in the grinders of the Elephant, inferred the American fossil to have been a gigantic carnivorous animal, which he proposed naming *Pseudelephant.*[2] The great reputation so justly attaching to the name of Hunter gave undue weight and a wide currency to this very erroneous opinion, and further led to the Mammoth of Siberia being commonly confounded under the same carnivorous notion with the Mastodon of North America.

Peter Camper, in the first instance, made a considerable step towards an accurate knowledge of the extinct animal, by the inference that its molar teeth had a greater analogy with those of the Elephant than of the Hippopotamus; and that, like the former, it was probably invested with a trunk and with tusks:[3] but he afterwards expressed doubts which compromised the value of his original observations, having been led to adopt the opinion of Michaëlis, that the animal belonged to the order *Bruta* of Linnæus; that it had no tusks, and differed greatly from the Elephant.[4] This error, as has been explained by Cuvier, arose from the inspection of a detached palate with grinders, the posterior part of which was mistaken, both by Michaëlis and by Camper, for the anterior.[5]

Pennant first ventured, in 1793, to designate the American fossil animal in a systematic work as a species of Elephant, by the name of *E. Americanus;* and Blumenbach, in 1797, erected it into a kind of genus, under the name of *Mammut Ohioticum*, which he briefly characterized by the form of the teeth. Cuvier in his earliest memoir on the Elephant, described it also as a species of this genus under the specific designation applied by Pennant of *E. Americanus*,[1] for which Adrian Camper, entertaining the same opinion of its generic relations, proposed the substitution of *E. macrocephalus*.[2] But in his second extended and elaborate memoir, published in 1805, which formed the groundwork of what he has written on the subject in the 'Ossemens Fossiles,' Cuvier separated the Elephants with mammillated molars from the ordinary forms with lamelliform molars, and united the former into a genus which he designated *Mastodon*, taking the North American species, under the name of *M. giganteum*, as the type.[3] In the interval between these two memoirs, Peale made the important discovery of two skeletons of the Ohio Fossil, near the banks of the Hudson River, in the State of New York, one of which was brought to Europe in 1802, and furnished nearly complete materials, for instituting a detailed comparison between the osseous frame of the Mastodon and of the existing Elephants.[4] Cuvier pointed out the entire correspondence between them in the tusks, trunk, and the whole of the skeleton, except the molar teeth. He admitted, even in regard to the latter, that the difference between the transverse mammillated ridges of the Mastodon, and the thin plates of the Elephants, is merely one of proportion; but insisted that there is an essential distinction in the circumstance that the spaces between the enamel ridges are filled with 'cement' in the teeth of the Elephant, which is wanting in those of the Mastodon. In addition to this supposed difference, he found corresponding modifications in the form of the cranium, which confirmed him in his view of a well-marked generic distinction between *Mastodon* and *Elephas*.[5] In the same memoir, Cuvier characterized four other species of his new genus, viz., *M. angustidens*, in which he included all the narrow Mastodon molars found in Europe, together with some from America; two species from South America, *M. Andium* and *M. Humboldtii;* and a small European species which he named *M. minutus.* To these were subsequently added, in the 'Ossemens Fossiles,' a sixth species, under the name of *M. Tapiroides.*

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[1] Collinson, Phil. Trans. 1768, vol. lvii. p. 469.

[2] W. Hunter, Phil. Trans. vol. lviii. p. 38.

[3] Camper, Acta Petropolit. tom. i. part 11, p. 219.

[4] *Idem, loc. cit.* tom. ii. p. 259.

[5] Oss. Foss. tom. i. p. 212.

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[1] 'E. Americanus, molaribus multicuspidibus lamellis post detritionem quadrilobatis." Cuvier, Memoir. de l'Institut. Ann. vii. (1798.) 'Sur les espèces d'Eléph. viv. et foss,' p. 21.

A Camper, 'Descript. Anatom. d'un Eléphant Male,' Avant Prop. Note, p. 10.

[3] Annales du Muséum d'Histoire Naturelle, tom. viii. 'Sur le grand Mastodonte.'

[4] R. Peale, 'Account of the Skeleton of the Mammoth,' &c.; and 'Historic. Disquisit.' 1802 and 1803.

[5] Oss. Foss. tom. i. p. 221.

In regard to the number and succession of the teeth, while he admitted eight molars on each side of both jaws to the Elephant, this great Anatomist, not hazarding a conjecture beyond the materials which had come under his eye, was not aware of more than four on each side in the Mastodon, or sixteen in all. He was also without the knowledge of the occasional presence of tusks in the lower jaw; but he first made the important observation, that in the *Mastodon angustidens* a part of the anterior series of molars in the upper jaw is replaced by a vertical successional tooth, or true premolar, thus bringing them under the normal law of the order of Pachydermata, by showing a division into a milk and permanent set. The Dax specimen, figured in the 'Ossemens Fossiles' (Divers Mast. Pl. 3. Fig. 2), clearly establishes this point; and the signification of the structure is distinctly, although guardedly, explained by Cuvier in the descriptive part of the work (tom. i. p. 256). But he was less happy in the definition of his species. Under the name of *Mastodon angustidens*, he has included two very distinct forms, characterized by a different numerical formula in the crown ridges, viz. *M. angustidens* and *M. longirostris;* and the South American teeth which he distributed among three nominal species, *M. angustidens*, *M. Andium*, and *M. Humboldtii*, appear to be all referable to a single form, *M. Andium* of M. de Blainville. We agree also with the latter authority, in considering the tooth upon which *M. minutus* is founded to be nothing more than an anterior molar of a young *M. angustidens.*

Cuvier's opinion was first called in question by Tilesius, in 1815, in his memoir upon the skeleton of the frozen Mammoth, discovered by Mr. Adams in Siberia.[1] He repudiates the validity of the grounds for separating Mastodon from Elephas, in terms of such strong dissent as to have excited the indignation of the French philosopher:[2] "Cuvierus in tractatu suo de hac specie (M. giganteus) quam injuste ab Elephantorum genere separavit quamquam non solum dentes molares, in quibus male genericam diversitam[3] quæsivit lamellosæ sunt structuræ, ut omnes reliqui Elephantorum molares sunt, sed etiam totum animal characteribus genericis Elephantorum respondeat ejusdem opinionis est." Cuvier's division, however, has been adopted by every subsequent writer except M. de Blainville, who coincides with the view taken by Tilesius.

A still more important oversight was made by the founder of the genus, in regard to the statement which he advanced of the entire absence of 'crusta petrosa,' or 'cortical' from the molars of Mastodon. It is true that this substance is not present in an appreciable quantity in *M. Ohioticus;* and that it is also but very sparingly developed in *M. angustidens* and *M. longirostris;* but in *M. Andium,* a typical form of the genus, this substance exists in a layer of considerable thickness, which we have observed in almost all the teeth of the species, contained in the museum of the Jardin des Plantes, including the specimens brought by Dombey, Humboldt, and Gay, from Chili and Peru, and also in the rich series of specimens from Buenos Ayres, lately acquired by the British Museum. The great weight of Cuvier's authority has given an undue influence to his statement upon this point, which has biassed the observations of some later writers directed to the subject.

No other additions were made to the species of *Mastodon* from the second edition of the 'Ossemens Fossiles' until 1826, when an important discovery was made, of fossil bones, along the banks of the Irawaddi River, in the Burmese Empire, by Mr. Crawfurd. These remains have been figured and described in the Geological Transactions, by Mr. Clift, who has made a valuable contribution to palæontology by proving the existence of two Indian fossil species, which, through the form and number of the coronal divisions of the molars, establish connecting links between *Elephas* and *Mastodon*. These he has named *M. Elephantoides* and *M. latidens*, and from their examination, he was led, with prescient sagacity, to anticipate the discovery of other forms which should constitute a complete transitional series between the two genera.[1] But Mr. Clift, like Cuvier, overlooked the presence of a coat of 'cement,' which is developed in such thickness in one of the species (*M. Elephantoides*) as to be of functional importance; and his two nominal species include teeth which appear to belong to several distinct forms.

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[1] Tilesius, Memoir. de l'Acad. Imperial des Sciences de St. Petersburg, tom. v. p. 452.

[2] Oss. Foss. tom. i. pp. 11 and 225.

[3] Sic in orig.

The next accession to the species of Mastodon was made in 1828, by Croizet and Jobert, who described certain fossil teeth and jaws from Auvergne, under the name of *M. Arvernensis*.[2] The specimens were chiefly jaw fragments, derived from very young animals, and the species was characterized by these palæontologists, as distinguished from the true *M. angustidens* of Cuvier, by the presence of a well-developed front and back 'talon' in each of the molars, and by the greater complexity in the composition of the crown ridges, which are irregularly subdivided into aggregations of small warty cones.

The observations of Croizet and Jobert were correct, so far as they went, and to them assuredly belongs the merit of having first recognised the distinctness of this much-disputed species, which is most frequently met with in authors under the name applied to it by Kaup of *M. longirostris*. But the most essential distinctive character escaped their notice. In the year following the publication of their work, Hermann von Meyer described under the same name a fragment of the upper jaw of a young Mastodon, from the celebrated deposit of Eppelsheim, containing the three first molars *in situ*.[3] After considering the characters indicated by Croizet and Jobert, he states that *M. Arvernensis* is distinguished from *M. maximus* (M. Ohioticus), *M. angustidens*, and all the other species then known, by the circumstance that the third molar in the order of antero-posterior succession has the crown divided into *four* ridges, while the same tooth in the other species presents only *three* ridges. In a subsequent memoir, on the fossil remains of Georgensmünd,[1] von Meyer figured and described several Mastodontine grinders, which he referred to the true *M. angustidens* of Cuvier, and which confirmed the constancy of the differential character between that species and *M. Arvernensis*, in the numerical division and form of the crown ridges, as pointed out by him in his previous memoir. This was the first step towards a satisfactory determination of the species, as distinct from *M. angustidens*; and a great mass of additional materials, confirming the same inference, was soon afterwards brought to light by Dr. Kaup; but, in the interim, new observations, of great interest, were made upon the Mastodon of North America, which gave an entirely different character to the investigation from this date.

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[1] Clift, Geol. Trans. 2nd Ser. vol. ii. p. 369.

[2] Croizet et Jobert, 'Recherch. sur les Oss. Foss. du Depart du Puy-de-Dôme,' 1828 p. 133.

[3] Hermann von Meyer, 'Ueber Mastodon Arvernensis bei Eppelsheim.' Nov. Act. Acad. Leop. Carol. Natur. Curios. 1829. Vol. xv. p. 113.

No suspicion appears to have been entertained before this time, that any of the Mastodons, more than the existing Elephants, possessed tusks in the lower jaw. Cuvier expressly affirms their absence,[2] although, as has been observed by Professor Owen,[3] he figured in the original memoir in the 'Annales du Muséum,' and in the first edition of the 'Ossemens Fossiles,' a lower jaw of an adult *Mastodon*, showing what appears to be the alveolus of a persistent inferior tusk. Early in 1830, a memoir by Dr. Godman was read to the American Philosophical Society,[4] upon a Mastodontoid lower jaw, with two small tusks, which he described as characterizing a distinct Proboscidean genus, under the name of *Tetracaulodon*. This jaw belonged to a young animal, and showed four molars on each side, the anterior two of which Godman considered to belong to the 'milk,' and the rest to the permanent series. These teeth resembled, in every respect, molars of the same size, in other specimens of the lower jaw, which exhibited no vestige of a tusk, and which were usually considered to belong to *M. Ohioticus*. Mr. W. Cooper, in consequence, immediately questioned the accuracy of Godman's inference, and insisted that the inferior tusks indicated merely differences dependent on age and probably sex; that they were possessed by the young animals, but were shed during the increase of age, the period of their fall varying with the individual.[1] Mr. Titian Peale suggested that these inferior tusks might be a distinctive mark of young males.[2] Dr. Harlan adopted the same view,[3] and referred to the corneous appendages in several genera of the Ruminantia as analogous distinctive characters between males and females. Notwithstanding the force of these objections, Dr. Isaac Hays, in 1831, not merely maintained the correctness of Dr. Godman's opinion regarding the distinctness of *Tetracaulodon*, but attempted to distinguish two additional species of this nominal genus under the titles of *T. Collinsii* and *T. Godmani*, besides two new North American species of *Mastodon*.[4] The memoir in which these opinions were advanced, is illustrated by an excellent and copious series of figures, exhibiting the dentition of *M. Ohioticus*, from a very early to the adult stage; and although Dr. Hays has entirely failed in sustaining the genus *Tetracaulodon*, or the species which he proposed, his memoir has served as an important contribution to palæontology, by showing that the number of molars developed during life, in *M. Ohioticus*, successively from behind, amounts to six. These he has traced, from the first to the last with great care, in the lower jaw, and established the position and characters of each by the comparison of a large number of specimens.

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[1] Museum Senckenbergianum. Die fossilen Zähne und Knochen von Georgensmünd, 1834, p. 33, Tab. 1 and 3.

[2] Oss. Foss. tom. i. p. 233.

[3] Owen, 'Odontography,' p. 619.

[4] Godman, 'Americ. Phil. Trans.' New Ser. vol. iii. p. 478. 'Tetracaulodon Mastodontoïdeum.'

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[1] W. Cooper, 'Lyceum of Nat. History of New York,' April 1830; 'Silliman's Journ.' vol. xix. p. 159; and Featherstonhaugh's 'Monthly Americ. Journ. of Geol.' vol. i. p. 158.

[2] Titian R. Peale, quoted in Dr. Hay's Memoir Amer. Phil. Trans. New Ser. vol. iv. p. 318.

[3] Harlan, 'Med. and Phys. Research.' p. 254.

[4] Hays, *loc. cit.* p. 317-337.

Whilst this discussion was taking place in America, the discovery was made of a similar structure in a European species of *Mastodon*, by Dr. Kaup. This distinguished palæontologist first proved the existence of two deflected and recurved tusks of large size, in the lower jaw of his colossal genus *Dinotherium*, the teeth of which had been referred by Cuvier to a gigantic kind of Tapir. Soon afterwards, at Eppelsheim, in the same arenaceous deposit which had yielded the Dinotherian remains, he discovered an adult lower jaw of a species of *Mastodon*, which presented a remarkable semi-cylindrical and beak-shaped elongation of the symphisis, forming the sheaths of two inferior tusks, while the molar teeth exhibited the characters attributed by Cuvier to a portion of the specimens included by him under the names of *M. angustidens*. Kaup, after recognising the structure, at first adopted Godman's genus for the reception of his species, which he named *T. longirostris*;[1] but, subsequently, in his great work upon the Eppelsheim fossils,[2] he admitted the force of the objections raised by the American naturalists against the generic importance of the inferior tusks in *Tetracaulodon*, and referred the Eppelsheim fossil to the genus *Mastodon*, retaining the same specific name. He extended the observations made by von Meyer on *M. Arvernensis*, which he considered to be the young of *M. longirostris*. He traced the dental succession from the earliest to the adult stage, confirming the observations made by Hays on *M. Ohioticus*, by showing that six molars are developed in the European species during life, in antero-posterior succession. Kaup also detected the presence of an upper premolar, situated as a germ, above the second deciduous grinder, in a young specimen of *M. longirostris*, corroborating the inference drawn by Cuvier from the Dax specimen of *M. angustidens*; but he considered this tooth as the normal successor of the first milk molar, the second of the series being the tooth which it specially replaces. Dr. Kaup, in the first instance, took a peculiar view of the affinities and systematic relations of his most remarkable genus *Dinotherium*; but he has since come round to the opinion advanced by other observers, that it was a true Pachydermatous form,[1] closely allied to *Mastodon.*

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[1] Isis, 1832, p. 628.

[2] Ossemens Fossiles de Darmstadt, 1835, Part iv. p. 65-89.

The discussion respecting *Tetracaulodon,* which had been suspended in America, was renewed in England on the occasion of Koch's public exhibition of the entire skeleton, and other remains of the North American *Mastodon,* in London, during 1841. The ingenious exhibitor contrived a fanciful reconstruction of the skeleton inconsistent with the principles of animal mechanics. The huge tusks, instead of being placed with their points directed upwards, as in the Elephant, or downwards, as had been formerly suggested by Mr. Rembrandt Peale,[2] were spread out horizontally with diverging curves, so as to resemble two great sickles. Other corresponding extravagancies were exhibited in the apposition of the limbs, and for the grotesque form so constructed, Mr. Koch proposed a distinct generic place, under the designation of *Missourium.*[3] Professor Owen, on this occasion, reviewed the whole of the evidence respecting *Tetracaulodon,* and, in a masterly communication to the Geological Society, extended the objections urged by the American naturalists, by numerous and forcible analogies drawn from the dentition of the Dugong and Narwahl, besides some of the ordinary Pachydermata.[4] He arrived at the conclusion, that the Mastodontoid animals of North America are all strictly referable to a single species, which "has two lower tusks originally in both sexes, and retains the right lower tusk only in the adult male." Dr. Grant entered upon an elaborate investigation of the same subject soon afterwards, and was led to very different results.[5] He divides the Proboscidean Pachydermata into four genera, *Elephas*, *Mastodon*, *Tetracaulodon*, and *Dinotherium*, to each of which he attributes a different dental formula. He admits thirteen species of *Mastodon*, and discriminates six species of *Tetracaulodon* among the *Mastodontoid* animals of North America. Mr. A. Nasmyth adopted similar views, from a minute microscopical examination of the structure of the tusks in these extinct animals;[1] but the importance of the differential marks indicated by Dr. Grant and Mr. Nasmyth, has not been admitted by subsequent observers, as characterizing more than individual and sexual varieties in different animals of the same species. The generally received opinion at present is, that *M. Ohioticus* is the only Mastodontoid form hitherto met with in North America.

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[1] Akten der Urwelt, 1841.

[2] Cuv. Oss. Foss. tom. i. p. 239.

[3] Koch has lately published a separate memoir, in which the *Missourium* is figured and perpetuated with all its original exaggeration. He has given it the appropriate specific name of *M. theristocaulodon,* the tusks being invested with the functions of a sort of scythe.—A. C. Koch, 'Die Riesenthiere der Urwelt oder das neu entdeckte Missourium theristocaulodon, und die Mastodonten im Allgemeinen und Besondern.' Berlin, 1845.

[4] Owen, 'Proceedings of the Geol. Soc.' Feb. 1842, vol. iii. p. 659; 'Report on the Missourium.'

[5] Grant, *loc. cit.* June 1842, p. 770, 'On the Structure and History of the Mastodontoid Animals of North America.'

In the additions to the last edition of the 'Ossemens Fossiles,' Cuvier has recorded the discovery of fossil grinders of Mastodon, in the Lignite beds of Kœpfnach and Ellg in Switzerland, which he has referred to his 'Mastodonte à dents étroites.'[2] Some of these remains have been described by Schinz as indicating a distinct species for which he has proposed the name of *M. Turicensis*.[3] M. de Blainville refers them to *M. Tapiroides*, as defined in the 'Ostéographie.'

Two species of Mastodon have been proposed by Eichwald, from remains found in Poland, under the names of *M. Podolicus*[4] and *M. intermedius*;[5] the former of which appears to be founded on a disguised fragment of the lower jaw of *Dinotherium giganteum*, and the evidence adduced in support of the latter is insufficient as yet to establish its specific independence. M. de Blainville refers it to *M. Tapiroides*.[6]

One of the authors has described some of the remains of a typical species of Mastodon, from the tertiary deposits of India, under the name of *M. Sivalensis,*[1] a detailed account of which will be given in this work.

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[1] Nasmyth, *loc. cit.* June 1842, p. 775, 'On the Minute Structure of the Tusks of Extinct Mastodontoid Animals.'

[2] Oss. Foss. 8vo. edit. 1834, tom. ii. p. 366.

[3] Schinz, quoted in von Meyer's 'Palæologica,' 1832, p. 72, and in Bronn's 'Jahrbuch' of 1839, p. 2; mentioned in Jameson's Edin. New Phil. Jour. vol. v. 1828, p. 273, as a communication to the Helvetic Society of Nat. Hist. in August 1837.

[4] Vide *supra*, note, p. 4.

[5] Eichwald, 'Zoologia Special.' 1831, vol. iii. p. 361.

[6] Ostéographie, 'Des Eléphants,' p. 259.

Professor Owen has proposed the provisional name of *M. Australis,*[2] for a form which rests upon a solitary specimen, brought from Australia. We shall have occasion to refer to this specimen in the sequel.

The grounds upon which Cuvier technically rested his generic distinction between *Mastodon* and *Elephas* having been invalidated by the discovery of the species named *M. Elephantoides* by Clift, it became necessary for systematic authors either to unite them under a single generic name, or to devise other diagnostic characters for their separation. Bronn, in his 'Lethæa,' gives an elaborate definition of the two genera founded upon the observations of his countrymen, Kaup and von Meyer, on the European species, and of the American naturalists upon *M. Ohioticus.* He characterizes *Mastodon*[3] by inferior tusks; by the presence simultaneously of a greater number of grinders in each jaw; and by the expulsion of the anterior tooth in the young animal by a vertically succeeding premolar. The distinctive characters of *Elephas* he defines to be, the absence of inferior tusks; a less number of more complex grinders at one time in the jaws; and the uniform antero-posterior succession of the whole series of molars without a vertical premolar. M. de Blainville, in his great work,[4] has given the most full and detailed account of the species of both genera, that has appeared since the publication of the 'Ossemens Fossiles,' and endeavoured, by original observation and by the collation of information drawn from every accessible source, to make his memoir a monograph of the subject, brought up to the state of our knowledge at the present day. Having satisfactorily proved that the number of molar teeth, developed in antero-posterior succession, in the Elephant, does not differ from that of the Mastodon, as had been previously supposed, he insists that the characters presented by the number as well as by the form of all the parts of the skeleton are alike in both ; that the separate bones are so precisely similar that, when met with detached, it is exceedingly difficult to decide whether they belong to Mastodon or to Elephant ; that, as regards the structure of the teeth, there is a series of intermediate gradations forming a passage from the one genus into the other ; and that the observed differences in these organs are systematically of no greater signification than as indicative of the kind of vegetable food upon which the several species subsisted.[1] Guided by these views, M. de Blainville has abandoned Cuvier's genus of Mastodon, and, like the earlier observers, he has united it with the Elephant, under the common generic name of *Elephas*, of which he forms two sections, *Lamellidontes* and *Mastodontes*. The former includes the Elephants proper, viz., the two existing species, with *E. primigenius* doubtfully admitted as a distinct form, and *E. latidens*, under which name he unites the two species *M. Elephantoides* and *M. latidens*, described by Clift. Of the second section, comprising the typical Mastodons, M. de Blainville admits only four species, viz., *E.* (M.) *Ohioticus*, *E. angustidens*, *E. Andium*, and *E. Tapiroides*, together with *M. Sivalensis* as a doubtfully established species. M. de Blainville's work is illustrated with an admirable series of representations of the osteology and dentition of the different species, and he has made a valuable contribution to the palæontology of the Proboscidea, by defining the character of *M. Andium*, which was distributed among several nominal species by Cuvier. He has also thrown considerable light on *M. Tapiroides*, by means of the materials collected by M. Lartet, in the south of France, which he has combined under this specific name, with remains derived from different parts of Europe. But there are weighty objections to the rest of the details of this portion of the 'Ostéographie.' Although the consideration of the teeth is of paramount importance in every question connected with zoological arrangement, it is to be remarked, that M. de Blainville has nowhere adverted to the occurrence of premolars in the upper jaw of certain species of Mastodon, the presence of which—first observed by Cuvier in *M. angustidens*—has been clearly established by Kaup in the young of *M. longirostris.* The author of the 'Ostéographie' describes them as equally wanting in the Mastodons and in the true Elephants. With respect to the species, while M. de Blainville has judiciously rejected a great many of the nominal forms which have been proposed on slender grounds, he appears in other cases to have pushed this numerical reduction too far, and to have mixed up under the same name species which are essentially distinct. This remark applies especially to the Indian fossil forms, three or four of which are combined under *E. latidens;* and to the European *M. angustidens*, which, as defined and illustrated in the 'Ostéographie,' includes two separate species.

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[1] Journ. Asiat. Soc. of Beng. vol. v. p. 294.

[2] Ann. of Nat. Hist. xiv. 1844, p. 296.

[3] Lethæa Geognostica, 1838, Band ii. p. 1233-1240.

[4] Ostéographie, 'Des Eléphants,' Fascic. xvi.

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[1] *Loc. cit.* p. 2.

Professor Owen has been engaged upon the same subject, contemporaneously with M. de Blainville. In addition to the memoir upon the North American Mastodon previously referred to, our eminent countryman has discussed the systematic relations of *Elephas* and *Mastodon*, in his 'British Fossil Mammalia,' and in his very valuable work upon the teeth, lately published. On the latter occasion, he showed, for the first time, that the molar teeth of the Elephants and Mastodon, while they agree with each other, form no exception from the normal division into sets, presented by the ordinary Pachydermata (supra p. 11), and that the apparent anomaly in the order of their succession, arises from the partial or total suppression of the successional series of premolars. In the former work, after describing the differences in the form of the teeth of the two genera, he adds :—

" A more important difference presents itself when the teeth of the typical species of Mastodon are compared with those of the Elephants, in reference to their structure. The dentine, or principal substance of the crown of the tooth, is covered by a very thick coat of dense and brittle enamel; a thin coat of cement is continued from the fangs upon the crown of the tooth, but this third substance does not fill up the interspaces of the divisions of the crown, as in the Elephant. Such, at least, is the character of the molar teeth of the first discovered species of Mastodon, which

Cuvier has termed *Mastodon giganteus* and *Mastodon angustidens.* Fossil remains of Proboscidians have subsequently been discovered, principally in the tertiary deposits of Asia, in which the number and depth of the clefts of the crown of the molar teeth, and the thickness of the intervening cement are so much increased, as to establish transitional characters between the lamello-tuberculate teeth of Elephants, and the mammillated molars of the typical Mastodons; showing that the characters deducible from the molar teeth are rather the distinguishing marks of species than of genera, in the gigantic proboscidian family of mammalian quadrupeds.

"Two dental characters, however, exist, though hitherto, I believe, unnoticed as such, which distinguish, in a well-marked and unequivocal manner, the genus *Mastodon*, from the genus *Elephas.* The first is the presence of two tusks in the lower jaw of both sexes of the *Mastodon*, one or both of which are retained in the male, and acquire a sufficiently conspicuous size, although small in proportion to the upper tusks, while both are early shed in the female. The second character is equally decisive; it is the displacement of the first and second molars in the vertical direction, by a tooth of a simpler form than the second, a true *dent de remplacement*,[1] developed above the deciduous teeth, in the upper, and below them in the under jaw.

"These two dental characters, which are of greater importance than many accepted by modern zoologists as sufficient demarkations of existing groups of mammalia, have been recognised in the species called *Mastodon giganteus*, most common in North America, and in the *Mastodon angustidens*, which is the prevailing species of Europe."

But the value of these alleged characters, as furnishing certain distinguishing marks between Mastodon and Elephant, is far from being absolute. It will be seen in the sequel that premolars, instead of being invariably wanting in the Elephants, are developed in greater number in one typical fossil species, than they are known to be in any ascertained species of Mastodon; while, on the other hand, they do not appear to be constant in every species of the latter group; and, although the inferior tusks have been observed in three species of Mastodon, there are other forms in which they have not yet been detected, even in specimens of the young animal.

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[1] 'British Foss. Mammal.' p. 273-4, and repeated in the 'Odontography,' p. 615. These characters were not overlooked by Bronn: the inferior tusks are included in his dental formula of Mastodon; and the displacement of the anterior grinder by a vertical successor is also adverted to.

With respect to the European species, Professor Owen considers, like M. de Blainville, that *M. angustidens* and *M. longirostris* belong to a single form; and he refers the whole of the elephantine remains which occur so plentifully in England, whether in the fluvio-marine crag, or in the superficial drift and gravel, also to a single species, *E. primigenius.* He describes the dentition of the Indian species, discovered by Clift, under the designation of *Transitional Mastodons.*

We shall now proceed to the special consideration of the teeth, as the organs which have the greatest share of influence in determining the modifications in the construction of the cranium, and in the development of the general form, presented by the different species in the Proboscidea.

§ II.—On the Structure and Form of the Molar Teeth.

Plates 1, 2, and 3 are intended to represent, by careful copies of nature, the modifications in structure and form exhibited by the molar teeth of the Proboscidea; they show, in vertical sections, a series of gradations, commencing with *Dinotherium* and *Mastodon Ohioticus* at one extremity, and running through the other species to *Elephas primigenius,* in which the greatest deviation from the ordinary form of a grinding tooth is met with.

Each molar in the *Proboscidea,*[1] as is the case with all other animals, is developed within a closed membranous sac, called the

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[1] The substance of the four following paragraphs is drawn from the admirable descriptions given by Cuvier in the Ossemens Fossiles, tom. i. p. 32, and by Owen in his valuable systematic work on the teeth. Odontography, p. 649.

capsule, which is lodged in a cavity of the maxillary bone, and which forms the mould, so to speak, of the tooth. The exterior of this sac is simple, while its internal surface is expanded into numerous folds, which determine the arrangement of the 'ivory,' 'enamel,' and 'cement,' entering into the composition of the tooth. From the bottom of the sac a gelatinous mass, the 'pulp nucleus,' is projected upwards, subdivided into transverse digitated plates or segments, varying in number, length, and thickness in different species, and more or less numerous in different molars of the same individual, according to the age of the tooth. These 'pulp' segments are attached only by their base, and attenuate gradually upwards to their summits, being entirely free from adhesion, either to the opposite side of the sac, or to the contiguous 'pulp' divisions. The ossification of this 'pulp nucleus,' by the deposition of calcareous matter within the cells of its tissue, constitutes the ivory core, or central part of the tooth, being the substance called 'dentine' by Professor Owen.

From the opposite or coronal side of the capsule, other folds or induplications are given off, which proceed into the spaces between the divisions of the 'pulp nucleus.' Their attachment is continued along the parietes of the sac, so that on every side, except the base, they envelope the processes of the 'pulp nucleus,' over which they are closely applied, interlocking with the latter; the two sets of processes thus forming productions from the interior of the sac which are opposed to each other in the manner of salient and re-entering angles. The ossification of these peripheral folds in a continuous surface constitutes the 'enamel,' or vitreous shell, which encloses the ivory core of the crown of the teeth, terminating abruptly where the fangs commence.

Exterior to, and following the folds of this 'enamel pulp,' there is another modification of the internal membrane of the sac, the ossification of which, during the last stage of the development of the tooth, constitutes the external 'cortical layer,' or 'cement,' which, in a crust of greater or less thickness, is continued over the enamel of the crown, and down upon the fangs. In the true

Elephants this cement substance completely fills up the hollows between the plates of enamel.

The production of the hard tooth takes place by a process of calcification, which commences in the summits of the 'ivory pulp' segments, the solidification extending gradually downwards along the digital processes, which unite into a transverse plate; and these plates, at their base, are combined so as to form the common body of ivory which occupies the central mass of the tooth. Simultaneously with this production of the ivory, a similar process of solidification goes on in the corresponding and contiguous portions of the 'enamel pulp,' forming a shell of enamel which is closely applied to, and moulded on the form of, the ivory segments and their digital subdivisions. When the calcification has reached the common base of ivory, the enamel plates covering the contiguous segments of ivory unite along their lines of junction in the bottom of the clefts between the ridges.

The basal mass of the 'pulp nucleus' is not connected in a continuous surface with the bottom of the sac, but, as it were, by pedicles which, after the solidification of the body of the tooth, elongate and become contracted, with more or less of subdivision. These pedicles undergo the same process of calcification, and form the fangs, by which the tooth is implanted in the jaws. The fangs bear a relation to the divisions and vertical height of the crown, being few, thick, and more or less distinct in the Mastodons, while they are numerous, slender, and confluent in the Elephants.

The three constituent dental substances are structurally distinguished by very different characters, and their combined modifications in the molar teeth furnish the best differential marks for the arrangement of the groups of *Mastodon* and *Elephas*, and for the discrimination of the different species.

The molars of the North American Mastodon, and of the existing Indian Elephant, may be selected as convenient illustrations of the opposite extremes of form presented by these teeth in the Elephantidæ. Taking the last tooth of the upper jaw as the example; in the former, the crown is nearly rectangular in outline, somewhat higher in front than behind, the dimensions being about seven inches in length, by four of width at the anterior end. The height of the crown, from the base of the enamel to the summit of the first ridge (vide Section, pl. 3, fig. 9), is about two and a half inches, decreasing a little successively to the fourth or last principal ridge. The grinding surface is divided in two directions, viz., longitudinally along the axis by a narrow cleft, which, as in the Hippopotamus and most other Pachydermata bisects it into nearly equal segments; and transversely by four deep open hollows, alternating with as many trenchant ridges. Each of the lateral divisions of these ridges is composed of a pair of compressed confluent points; in the upper molars the outer division is more elevated, and slopes gradually towards the inner side which, although lower, is the most complex in composition, giving off the 'talons' and accessory tubercles, which are more or less developed in different species, the inner points being commonly the largest. This relation continues during the wear of the teeth, the inner side being more worn by the process of trituration than the outer. The teeth of the lower jaw agree with the upper in the form and subdivision of the crown; but the disposition of the lateral segments is reversed, the inner being higher, and continuing so during the wear, while the outer are lower, but more complex in composition. The higher and lower portions of the crowns of the opposed teeth are thus brought to act against each other, and serve more effectually the triturating function of the teeth. The plane of the grinding surface is nearly level from back to front, both in the upper and inferior grinders. In consequence of the peculiar mode of protrusion of the teeth, from behind forwards, the crown ridges come successively into use, commencing with the first, and each of the lateral divisions is ground down to a rhomboidal disc, surrounded by a band of thick enamel: as the wear of the tooth advances, the separate discs unite, forming a wide transverse depression corresponding to the configuration of the ivory nucleus, and the shell of enamel which invests it. The 'cement,' or third dental substance, is very sparingly developed upon the crowns of the molars of the

North American Mastodon, being only distinguishable in a thin layer under the microscope. It is more abundant upon the fangs. The anterior ridge is supported by two stout united fangs, and the three posterior ridges by fangs agreeing with them in number, but more or less confluent into an irregular hollow cone.

In the existing Indian Elephant, the last grinder of the upper jaw is of a subtriangular rhomboidal form in the vertical section, widely different from that of the North American Mastodon. The crown is very high in front, and declines rapidly behind. In a large specimen of this tooth from Assam, the dimensions are upwards of fourteen inches of length, by eight inches of height in front, which is reduced to about one-third at the last ridge, while the width does not exceed three inches at the anterior end, from which it narrows gradually behind. The coronal surface is convex across, and also in the antero-posterior direction. There is no indication of the longitudinal cleft, which, in the North American and other Mastodons, bisects the crowns of the molars into lateral segments. The ridges, which in the first-mentioned species do not exceed four, are multiplied in the last upper grinder of the Indian Elephant to twenty-three or twenty-four thin plates, which terminate upwards in slender, cylindrical digitations, hence called *Cheirolites*, by the early palæontologists, when found separate. The cement substance enters largely into the composition of the tooth, being interstratified with the enamel plates in a layer which also envelopes the entire body of the tooth. The fangs are slender, and numerous, bearing a relation to the lamellæ but they are confluent into large hollow groups, which are of inconsiderable length, as the tooth is held firm in the jaw by a large portion of the crown being imbedded in the alveolus. Instead of being protruded in a nearly horizontal direction, as in the North American Mastodon, the teeth move forwards in the arc of a circle ; the anterior plates in the upper grinders are inclined forwards, and by the process of wear they are ground down, so that the front part of the tooth is truncated obliquely (pl. 1, fig. 2, and pl. 7, fig. 4.) long before the posterior lamellæ come into use. The plane of detrition makes a large angle with the unworn plane of the crown, and in the upper grinders it slopes from the inside outwards, being the reverse of what takes place in the Mastodons. In the lower jaw, the crown of the last molar is concave from behind forwards, and convex across; the grinding plates, especially towards the posterior end, recline backwards, and the plane of wear, which is concave, slopes from the outside inwards, bearing a reversed relation to that of the upper jaw. The side of the jaw to which the teeth belong is readily distinguished by these characters, and by the circumstance that the upper grinders are convex on the outer, and concave on the inner side, the reverse taking place in the grinders of the lower jaw. The last inferior molar attains a length of fifteen inches, and presents occasionally as many as twenty-six or twenty-seven constituent plates in the largest sized individuals of the Indian Elephant.

When the teeth come into use, the digitated summits of the anterior ridges are first ground down into circular rings of enamel enclosing a pit of ivory; these rings then unite into oval groups (pl. 7, fig. 4*a*); and as the wear descends below their point of separation, the smaller discs disappear in a common transverse band which is bounded by a projecting edge, or *machæris* of enamel. These edges, which represent a transverse section of the enamel plates, either run across in straight and parallel lines, or they are minutely crimped and undulated, or dilated into round loops, or angular expansions in the middle of the ridge: such modifications holding with great constancy in the different species, and yielding the characters by which they are most readily distinguished. The three constituent dental substances being of unequal hardness, are worn unequally by the process of trituration; the hard enamel projects above the ivory, and the softer cement wears quicker than either. The grinding plane of the tooth thus presents, throughout its period of duration, a surface highly organised by natural inequalities, to serve a constant triturating purpose. As the anterior lamellæ are worn down, the corresponding fangs are gradually absorbed.

Between these extremes, furnished by the North American

Mastodon and the existing Indian Elephant, there is a series of intermediate forms, which establishes an almost unbroken passage from the one into the other.

Fig. 6*a*, pl. 2, represents a vertical and longitudinal section of the last upper molar of an Indian fossil species, which we have named *Elephas insignis* in this work. It is selected as furnishing the best illustration of the intermediate type of a proboscidean molar tooth, from which those of the other species diverge in opposite directions. It is in the most favourable state of age and use for showing the characters, the four anterior ridges being affected by wear, and the six posterior ridges entire, while the fangs are fully developed, their mode of implantation in the jaw being distinctly shown. The tooth is convex from back to front, in the outline of the crown. The white mass in the centre represents the body of ivory, which is projected upwards in ten angular lobes terminating in a sharp edge. The height of these lobes does not much exceed the width of their base, and closely applied over them is seen a thick layer of enamel, reflected up and down in a continuous zig-zag plate. The interspaces of the five posterior ridges of enamel are completely filled up by a mass of cement, or 'cortical,' much exceeding the enamel in thickness; and in quantity in nearly as great an amount of development as the ivory core of the ridge. This tooth belongs to one of the forms which have been included under the name of *Mast. Elephantoides*, by Mr. Clift; and which Professor Owen names 'Transitional Mastodons.' It is important to observe the characters presented by the cement in this case, as its supposed absence or presence in the molar teeth was the principal character upon which Cuvier rested his generic distinction between *Mastodon* and *Elephant*. Professor Owen, in his Odontography, states, in regard to the teeth of this species, that, "the interspaces are not filled with cement, as in the true elephant: only a thin layer of that substance is continued upon the unworn enamel, as in the true Mastodons."[1] But this statement must be received with some modification. Fig. 7, pl. 6, represents a portion of the same section drawn to the natural size, and comprising the sixth and seventh ridges. The cement exhibits an appearance of lamination, of which from nine to eleven layers may be counted, and is developed in as great a quantity as the intervals between the ridges could admit of. The four anterior ridges have been well used, so that the two first are worn down to a common disc, from which the enamel has disappeared; and the cement of the four anterior hollows, being the softest of the tooth substances, has been completely, or partially, worn away by the same process of detrition. The dark granulated shade below the portion of the ivory nucleus which sustains the five posterior ridges, indicates, in the figure, the hollow of their common posterior fang, which is occupied in the fossil by a core of sandstone; the same matrix also fills the cells of the maxillary bone. The anterior simple fang is shown in the section, of much smaller size. This tooth measures 10.3 inches in length.

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[1] Odontography, p. 624.

Fig. 6 *b*, represents a similar section of the anterior portion of an adult tooth of the lower jaw of the same species. In this instance the two front ridges only, have been touched by wear. Instead of being convex, the common curve of the crown is slightly concave. The ivory, enamel, and cement present the same characters as in the upper molar, except that the cement in the interspaces is less considerable in quantity, although sufficiently abundant to indicate that it was functionally serviceable in the grinding operation of the tooth. The posterior part of the basal portion of the pulp nucleus had not yet completed the stage of calcification, its place being occupied in the fossil by a nest of calcareous crystals, bounded in the figure by the undulated line. The figure shows also a portion comprising the two last ridges of the preceding molar, with their common fang implanted in the lower jaw.

The next serial modification in the disposition of the three dental substances, and in the consequent form of the teeth, is exhibited in fig. 5 *a* of the same plate, which represents a section of the penultimate upper molar of another Indian fossil species which we have named *E. planifrons.* This tooth shows nine ridges, the three anterior of which alone have been in use, the two first being worn down to a single disc of ivory. The common nucleus of this substance is of less thickness than in the corresponding tooth of *E. insignis*, and the divisions which are continued upwards from it into the centre of the ridges are more elongated, with a narrower base, forming irregular-shaped wedges. The layer of enamel is diminished in thickness and is less uniform in outline, and the surface in contact with the cement shows a feathered or ragged edge, indicating superficial inequalities for the firmer cohesion of this latter substance. The enamel is reflected over the ridges of ivory, and down into the hollows zig-zag wise, exactly as in fig. 6 *a*, the principal difference being that the ridges are narrower, with a greater vertical height. The cement substance attains its maximum of development in this species, completely filling up the wide interspaces of the ridges, over which it is continued in a thick mass. This tooth measures 8.7 inches in length.

Fig. 5 *b*, represents a corresponding section of a portion of the last molar of the lower jaw of the same species, comprising nine ridges. This tooth had been longer in use than that of the upper jaw, and all the ridges are more or less worn except the two last. It presents the same general characters exhibited by fig. 5 *a*, in the elongated cuneiform ivory ridges, unequal enamel, and abundant cement, the differences being merely such as constantly hold between molars of the upper and lower jaws, and of different ages in the same species.

The existing African Elephant furnishes another link in the chain of modifications presented by the molars in this family. Fig. 4 *a*,[1] shows a section of the penultimate grinder of the upper jaw of this species, which is composed of nine principal divisions and a subordinate 'talon' ridge, the four anterior of which are partly worn, the rest being entire. The elongation of the ivory segments, which commences in *E. planifrons*, is carried here to a much greater extent. The segments are produced into long

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[1] We are indebted to the kindness of Mr. Charles Stokes for the specimens which have yielded the sections 4 *a* and 4 *b* of the African Elephant, the teeth of this species being comparatively rare in English collections.

narrow wedge-shaped plates, the height of which is many times greater than the width of their base. The interspaces of the plates are proportionally deep, and filled up with a copious mass of cement, which completely envelopes the tooth. The quantity of this substance is measured by the proportion which it bears to the other dental materials, and it is seen to be thicker than the ivory plates. The layer of enamel is reflected over the ridges and down upon the hollows as in *E. insignis*, but it is much thinner, and the attenuation is proportioned to the elongation of the plates. The common basal mass of ivory is greatly reduced in quantity, if compared either with the sections of *E. insignis*, fig. 6 *a*, or of *E. planifrons*, fig. 5 *a*, there being little more of this substance than is sufficient to establish a common connection between the bases of the segments, and a foundation for the offset of the fangs, which are numerous. The vertical height of the tooth is considerably greater than that of either of the two other described species. This tooth measures 8.7 inches in length.

Fig. 4 *b*, represents a penultimate molar of the lower jaw of the same species in vertical section. Like that of the upper jaw, it is composed of nine cuneiform plates. This tooth had been a long time in use, all the plates except the last being affected by wear. The anterior part of the, crown has been ground down to nearly one-third of its original height, so that the enamel divisions between the two anterior ivory plates have disappeared, and the latter are confluent into a common mass. It is not, therefore, in the condition best adapted to show the characters presented by a good section; but it indicates sufficiently the correspondence of the lower with the upper molars, in the disposition, form, and relative proportion of the ivory, enamel, and cement substances. It bears a very close resemblance to the section of the lower molar of *E. planifrons*, fig. 5 *b*, keeping in mind, that the latter is taken from an older and larger tooth. They exhibit the same kind of wedge-shaped ivory plates, a similar amount of cement in the interspaces, and an analogous thickness of enamel. The resemblance between the lower, in these instances, is greater than between the corresponding upper molars of the two species. This specimen measures 7.2 inches in length.

If the eye is carried along these sections in succession, it will be readily perceived that they constitute a series of gradations in form conducted from *E. insignis* to *E. Africanus*, through *E. planifrons*. The modifications are effected by the elongation and thinning of the ridge-plates, with a corresponding increase in the depth of the hollows, and in the vertical height of the teeth; by a diminution of the basal mass of ivory; by a greater number of divisions in the same extent of tooth surface, and a gradual diminution in the thickness of the layer of enamel. Plate 1, represents another succession of links which, in like manner, conduct us from the African Elephant on to the extremity of the series in *E. primigenius*.

Fig. 3 *a*, of this plate shows a section of the penultimate upper molar of an undescribed Indian fossil species named *E. Hysudricus* in this work. The tooth is in the middle stage of wear, eleven of the thirteen plates of which it is composed, having been in use, and the two anterior ridges being worn out. The same vertical disposition of ivory, enamel, and cement, is presented as in the African Elephant, but the plates are thinner and a greater number of them is included in the same length, nine or ten plates in the latter being developed in the space occupied by thirteen or fourteen plates in the equivalent teeth of *E. Hysudricus*. The plates are also more vertical, the interspaces occupied by the cement are wider in general than the ivory plates which represent very attenuated wedges. The layer of enamel is proportionally thicker than in the African Elephant, approaching, in this respect, the teeth of *E. planifrons*, fig. 5. The vertical height of the tooth is comparatively less in this specimen than in the African species, the difference being compensated by a greater development of the basal mass of ivory. . This specimen measures 7.7 inches in length.

A portion of the last molar of the lower jaw of this species is shown in vertical section in fig. 3 *b*, comprising about fifteen plates. The entire tooth, which is seen in figs. 12 and 12 *a* of pl. 7, *in situ* in the jaw, is more elongated, and includes a greater number of divisions than is usual in the last inferior grinder of *E. Hysudricus.* The same general character, in the disposition and relative proportion of the ivory, enamel, and cement, are exhibited as in the upper molar (fig. 3 *a*), bearing in mind that the latter is a younger and consequently smaller tooth. The layer of enamel, however, is thinner than in the upper molar, owing to the unusually large number of developed plates. The ivory segments are curved backwards near their base, and the apices of the posterior plates lean towards the front of the tooth, a disposition which is still more strongly exhibited in the lower teeth of the existing Indian Elephant. The granulated dark shade, below the undulated outline of the ivory, indicates a core of sandstone, which occupies the place of the unossified part of the pulp nucleus, and of the undeveloped fangs. Both specimens, 3 *a* and 3 *b*, are implanted in portions of the jaws.

The existing Asiatic Elephant, *E. Indicus,* furnishes the next modification represented in this plate. Fig. 2 *a,* shows a section of the penultimate upper molar of this species. The gradual attenuation of the plates, successively exhibited from *E. insignis* to *E. Hysudricus,* is here carried to excess, eighteen of these divisions being comprised within the space occupied by about nine in the equivalent tooth of the African species. They are produced vertically in the same proportion, the height of the middle plate being about three-fourths of the entire length of the tooth; they, in fact, represent parallel perpendicular lamellæ, of nearly uniform thickness, from the base to the apex, interstratified with layers of cement of nearly the same thickness. The layer of enamel is attenuated into a thin transversely undulated brittle plate, the surface of which is deeply wrinkled with striæ, for the firm cohesion of the cement. The general character of the section is a pectinated arrangement of the lobes like the teeth of a comb, which contrasts strongly with the chevron-formed ridges of *E. insignis,* and the cuneiform plates of *E. planifrons.* The mass of ivory at the base of the tooth is much thinner than in the corresponding molar of *E. Hysudricus*, bearing but a very slender proportion to the height of the tooth; and numerous small and distinct fangs are given off from its inferior edge. This tooth had been some time in use, the anterior part of the crown being worn off as far as the ninth plate. The plane of the truncated portion is very oblique, being inclined nearly at a right angle to the coronal surface of the unworn portion. This specimen is 8.2 inches in length.

Fig. 2 *b* represents the section of a very fine specimen of the last inferior molar of the existing Indian Elephant of Assam, from the collection at the India House. It is an unusually large specimen, showing as many as twenty-seven plates, the anterior twelve of which have been in use. Precisely the same disposition of the dental substances is observed in this case as in the upper grinder, and they are developed in the same relative proportions. The vertical height of the plates is still greater than in the corresponding lower molar of *E. Hysudricus*. The upper surface is concave, and the under very convex. The anterior plates are nearly vertical, while the posterior gradually slope backwards till they become almost horizontal in the hindmost portion, with a corresponding gradual diminution in their height. This is a mechanical arrangement arising from the contracted diameter of the posterior part of the dental canal, in which the back part of the tooth is developed, close under the condyle, the plates being disposed so as to occupy the least vertical space. The basal mass of ivory between the plates and the fangs is reduced to a small quantity. This tooth measures 15¼ inches long in a straight line.[1]

Fig. 1 represents a section of the last upper molar of *E. primigenius*, from an English specimen in the museum of the Geological Society, found near Kingsland. We arrive here at the last link in the chain of modifications, exhibited by the molar of the typical Elephants. The section bears a close resemblance to that

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[1] The artist has drawn this figure reversed, as compared with the other sections, the worn end of the tooth being to the right. The same remark applies to fig. 6 *a* of pl. 2. In pl. 1 the Indian Elephant has been named in the reference *E. Asiaticus* (Blum.) instead of *E. Indicus*.

of the corresponding tooth of the Indian Elephant, but the ivory segments are more vertical, thinner, and more approximated; there being about twenty-two plates in the space occupied by eighteen or nineteen in the latter; and the layer of enamel is still more reduced in thickness. The disposition of the plates presents the extreme degree of 'pectination' seen in the molars of any known species of Elephant. The differences observable in the vertical section are, however, so inconsiderable, that, if regarded in this light merely, the Mammoth and the Indian Elephant might pass for the same species. But when the grinding surface of the crowns of their molars is examined, the transverse plates of enamel in the Indian Elephant are seen to be thicker and very closely undulated, with the flexures deeply wrinkled for the attachment of the stratum of cement; while in the Mammoth the crowns of the teeth are broader, the enamel plates are thinner and less undulated, so much so that they are frequently described as being transverse and straight. Such at least is the character of the typical form of grinder in *E. primigenius.* This tooth measures ten inches in length, being considerably under the size attained by the largest specimens of the Mammoth. It has not been deemed necessary to give a figure of the section of an inferior molar, which differs in no respect from the upper, more than in the case of the existing Indian species.

These are the principal modifications in the construction of the teeth of the Elephants. Although, at first sight, the molars of *E. insignis* and *E. primigenius* appear to be very different, the other intermediate forms constitute a series which establishes a passage between them. The species have been traced in a retrograde order, from the simpler to the more complex forms, with the object of making the descriptions more intelligible. It is interesting here to observe how the existing species are intercalated: the serial order of structural development in the teeth does not correspond with the order of succession of the species in time. The extinct Mammoth exhibits the greatest amount of complexity, constituting the terminal link of the chain; and next follows the existing Indian Elephant, interposed between two fossil species. In like manner, the existing African Elephant is placed between two extinct species, *E. Hysudricus* and *E. planifrons*. The three plates of sections include only the principal forms requisite to establish the passage. Another extinct Indian species *E. Namadicus* (to be described in the sequel), which is closely allied to the existing Indian form, comes between it and *E. Hysudricus*, together with a European fossil species, which we believe to be distinct from the Mammoth ; and the gap between the existing African Elephant and *E. planifrons* is filled up by another well-marked European fossil species, *E. priscus* (?), pl. 13, fig. 7, which is closely allied to the former. This species will also be noticed in a subsequent page.

We shall now revert to *E. insignis*, and endeavour to trace the forms which diverge from it in an opposite direction through the Mastodons, the tendency in this series being towards a greater simplicity in the construction of the grinders, and a reduction in the number of coronal segments.

Fig. 7 *a*, pl. 3., represents a section of the last upper molar of an undescribed Indian fossil species, named *E. Ganesa*, in this work. The crown consists of ten principal ridges, with a subordinate 'talon' ridge in front and behind. The anterior seven ridges have their summits worn, the two in front being ground down to the common base of ivory, the tooth having been a considerable time in use. A small portion is broken off at the anterior end. The disposition and relative proportions of the ivory, enamel, and cement, bear the closest resemblance to those of the corresponding tooth of *E. insignis* (pl. 2, fig. 6 *a*), and the number of ridges agrees. The section presents the same chevron-formed character in the ridges, but the interspaces are narrower, the cement is in less quantity, and the layer of enamel is thicker. The common grinding surface of the crown is also less convex. But these differences are so inconsiderable, when taken into account with the range of variation through which the molars run, that they are practically insufficient for the discrimination of the two species. To guard against error, the sections have been taken in both instances from specimens consisting of the palate with a double line of teeth; and, notwithstanding that the molars agree so closely, the crania are remarkably different in the two forms; that of *E. insignis*, pl. 15, being singularly modified so as to bear an analogy to the cranium of *Dinotherium giganteum;* while the head of *E. Ganesa* does not differ much from the ordinary type of the Elephant. In fact, we have entirely failed in the detection of any good characters by which the teeth of these two species can be distinguished satisfactorily when met with in fragments, as is most generally the case. A similar agreement in the form of the teeth is observable in certain closely-allied species of Mastodon. The tooth represented in this section measures nine inches and a quarter in length.

Fig. 7 *b*, shows a section of one of the posterior molars of a lower jaw, which we infer to belong to the same species. A small portion of the anterior end of the crown has been broken off; but the presence of the anterior fang proves that the section includes the whole length of the tooth except the first ridge, the posterior end being entire. It appears to have consisted of eight principal ridges, with a 'talon' ridge behind, and a subordinate ridge in front. Five of the ridges have been in use, the anterior two in the section being worn down close to the common base of ivory, while the three last ridges are entire. Like the upper molar of *E. Ganesa*, it bears a close resemblance to the corresponding inferior tooth of *E. insignis* (pl. 2. fig. 6), in the form of the ridges, thickness of enamel, and proportion of cement. This specimen measures about seven inches and a half in length.

The next serial modification in the form of the molars occurs in another extinct Sewalik species, named *E. bombifrons*, in this work. It is not included among the sections in pl. 3. This species, of the distinctness of which we are assured, by possessing several crania containing perfect teeth, belongs to the same group as the two species last described. The crown is divided into similar transverse ridges, composed of numerous mammillæ, which yield a corresponding chevron-shaped section, and the interspaces are occupied by a thick coat of cement; but they differ, in being broader and less elevated, with more open hollows. The principal ridges of the last molar do not exceed eight in the upper jaw, and nine in the lower; while in *E. insignis* they amount to ten in the former, and reach as many as thirteen in the latter. The last tooth of the upper jaw measures eleven inches in length, by four and a half in width. This species will be described in detail in a subsequent chapter.

The same group comprises a fourth extinct Indian species, named in this work, *E. Cliftii*, which furnishes the next link in the chain of forms presented by the molars of the Elephantidæ. It is not figured among the sections in pl. 3. In our view, the tooth represented in pl. 39, fig. 6, of Mr. Clift's memoir in the Geological Transactions, under the name of *Mastodon Elephantoides*, and the palate specimen represented in pl. 36 of the same memoir, under the name of *M. latidens*, belong to this species.[1] The reasons for this opinion will be given, along with the detailed description of the species. The penultimate and antepenultimate molars in the upper jaw have only six transverse ridges, continuous, and chevron shaped, with numerous mammillæ, as in *E. insignis* and *E. Ganesa;* but the cement does not fill up the interspaces of the ridges, being reduced to a comparatively inconsiderable quantity in the bottom of the hollows. *E. Cliftii*, in the reduced number of the coronal ridges, and in the other characters of the teeth, appears to constitute the dental link which forms the immediate passage from *Elephas* into *Mastodon*. Mr. Clift, in reference to his *M. Elephantoides*, and *M. latidens*, has justly remarked, that, "On an examination of the structure of the teeth, this discovery" (viz. of these two species) "will be found to have still higher claims to attention; for it illustrates the gradual shades of difference by which nature passes almost imperceptibly from one form to another, and helps to fill up the interval which has hitherto separated the Mastodon from the Elephant."[2]

The three species last described, along with *E. insignis*, constitute a peculiar section of *Elephas*, of nearly equivalent value to the section which includes *E. primigenius*, *E. Indicus*, and

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[1] Geol. Trans. 2nd Ser. vol. ii. p. 369.

[2] *Idem, loc. cit.* p. 370.

E. Hysudricus. That they belong to *Elephas* proper, rather than to *Mastodon*, is clearly indicated by all the principal characters of the teeth: viz. the crowns are divided into many transverse ridges, consisting of numerous mammillæ resembling the digital terminations of the plates in the Indian Elephant; the hollows are occupied by a more or less abundant layer of cement; and, as in the typical Elephants, there is no appearance of the longitudinal cleft along the axis, which, in almost all the species of *Mastodon*, bisects the crown into lateral divisions. The same direction of affinity is indicated by the characters presented by the crania.

We here take leave, for a time, of the proper Elephantine forms; and from this point the complexity in the molars gradually diminishes till they assimilate to the character exhibited by the ordinary Pachydermata.

Fig. 8 of pl. 3 shows a section of another of the specimens described in Mr. Clift's memoir under the name of *Mastodon latidens*,[1] and represented by him in pl. 37. fig. 1. It consists of the two last molars of the upper jaw. The figure is drawn on a scale of two-thirds of the natural size. The last tooth shows five principal ridges with a posterior talon ridge and a subordinate ridge in front. The ridges are transverse, and divided by a longitudinal cleft into two pairs of principal points without intermediate mammillæ in the hollows. The enamel is very thick, and the cement is reduced to a thin layer which is only observable in the bottom of the hollows. The ivory lobes resemble those of *E. Ganesa*, fig. 7 *a*, but they are less elevated with a broader base. The artist has been eminently successful in his representation of the texture of the two dental substances in this specimen. The anterior tooth had been a long time in use, and the ridges are nearly all worn out. They were four in number, in this as well as in the two teeth which preceded it in the jaw. We believe this to be a small or dwarf variety of *M. latidens*, a species the adult teeth of which generally attain a large size. The last tooth figured in the section measures 5½ inches in length. *M. latidens*, of the known forms of Mastodon, is that which is most nearly allied to *E. Cliftii*, and through that species to the true Elephants. One or more intermediate links perhaps still remain to be discovered. It closely resembles the European *M. Arvernensis* (M. longirostris of Kaup) in the form of the molars. The correspondence is so great, in the last milk molar, and in the antepenultimate and penultimate true molars, that they have been regarded as identical species.

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[1] This valuable specimen, discovered by Mr. Crawfurd in Ava, belongs to the collection of the Geological Society, the President of which has liberally allowed a section of it to be made for the illustration given in fig. 8.

Fig. 10*a* represents a section of the last molar of the upper jaw of an Indian fossil species named *Mastodon Sivalensis* in this work. The ridges in this species are more complex in their composition than in *M. latidens*. The crown is traversed by a longitudinal furrow which bisects them, each division being composed of a pair of contiguous or connate conical mammillæ, placed more or less alternately. The hollows are in consequence interrupted. This tooth, like its equivalent in *M. latidens*, consists of five principal ridges, with a subordinate ridge in front, and a 'talon' ridge behind. Eight divisions of the ivory may be counted in the figure, the smaller segments arising from the direction in which the section has been made through the alternate mammillæ. The ridges are approximated, and the layer of enamel bears a large proportion to the conical lobe of ivory which it invests. The cement is entirely wanting, except in the bottom of the clefts. This tooth measures about seven inches in length.

Fig. 10 *b* shows a section of a fragment comprising the greater part of the last lower molar of the same species. There is a similar alternate arrangement of the mammillæ, and the tooth differs from the corresponding upper molar, only in being complicated with an additional ridge.

The teeth of this species bear an exceedingly close resemblance to certain of the European fossil grinders, which have been described under the indefinite name of *M. angustidens*. The three species, *M. latidens*, *M. Arvernensis*, and *M. Sivalensis*, with perhaps a fourth, of doubtful determination, constitute a particular section of *Mastodon*, characterized by the same numerical division of the crown ridges in the last deciduous molar, and in the first and second true molars in both jaws.

Fig. 9, as previously described, represents a section of the last upper molar of *Mastodon Ohioticus.* It consists of four principal ridges, and a small talon lobe. The successively increasing simplicity of form which has been traced from *E. insignis,* attains its extreme limit in the molars of this species. The ridges are transverse, terminating in a trenchant edge; the ivory segments are in regular angular lobes, the layer of enamel is of uniform thickness, and the hollows between the ridges are very wide and open, being almost rounded at the bottom. The cement is present only in an exceedingly thin crust, continued over the fangs in greater thickness. The common plane of the grinding ridges of the crown is nearly horizontal, while it is more or less convex in all the previously noticed species. It has not been deemed necessary to give a delineation of the section of an inferior molar, which differs in no respect from the upper, except in being complicated with an additional ridge.

To the same group belong two other species, *M. angustidens* and *M. Andium,* and probably a third, *M. Tapiroides,* the dentition of which is but imperfectly known. The molars of the two first differ from those of *M. Ohioticus,* in the same manner that *M. Arvernensis* and *M. Sivalensis* differ from *M. latidens;* viz., the crown ridges, instead of being transverse, are composed of mammillæ, which are placed more or less alternately, projecting into the interspaces, and interrupting their continuity. The teeth of *M. Andium* are remarkable in being invested with a coat of cement, which fills up the bottom of the hollows, and is extended over the mammillæ in a considerably greater quantity than occurs in any other species of true *Mastodon.* These three species, *M. Ohioticus, M. angustidens,* and *M. Andium,* constitute a distinct section, agreeing in having the three molars which precede the last, viz., the third deciduous molar, and the penultimate and antepenultimate true molars, uniformly characterized by having their crown divided into *three* ridges in both jaws; while the same teeth in the preceding group have each a crown with *four* ridges.

The teeth of *M. Andium* and *M. angustidens* are not included in the plates of sections. Following the same serial arrangement which has been observed throughout, their place would be between *M. Sivalensis* and *M. Ohioticus*, the latter of which forms the terminal link in the chain, establishing the nearest passage into *Dinotherium*, and through that genus into the ordinary Pachydermata.

Figs. 11 and 12 of pl. 3, drawn of the natural size, represent sections of the penultimate lower molar of two species of *Dinotherium*, the former a fragment, showing the posterior half of the tooth in *D. Indicum*, and the latter the whole tooth in *D. giganteum*. The sections exhibit the same arrangement of the dental substances as in *M. Ohioticus*. The tooth, fig. 12, consists of two transverse crenulated ridges, and a talon ridge, while in the equivalent molar of *M. Ohioticus*, there are three principal ridges. Corresponding to the smaller number of divisions, the ridges in *D. giganteum* are more widely separated, less elevated, and broader at their base, while the interspaces are also wider and more open than in the North American Mastodon; the layer of enamel is of similar thickness, and there is no appreciable crust of cement. The correspondence is followed out in the form of the subordinate heel ridge. *D. Indicum* is the species which is most nearly allied to *M. Ohioticus;* and all the ascertained evidence regarding it tends to prove that it belonged to a true Proboscidean pachydermatous genus like the latter.

§ III.—ON THE SUCCESSION OF THE MOLARS, AND THEIR CHARACTERS AS INDICATING SECTIONAL GROUPS OF SPECIES.

The molar teeth, developed during the course of life in the ordinary Pachydermata, are divisible into three well-marked sets; the milk or deciduous molars, the false molars or successional premolars, and lastly, the true molars. The milk teeth are so distinct in their transitory character, from the permanent series, that the consideration of the former is usually omitted in the construction of generic definitions; but in *Mastodon* and *Elephas*, the succession of the teeth is so modified, and the premolars are so completely, or partially suppressed, that the triple division is rendered very obscure, and it has commonly been found necessary, by systematic authors, to include the whole series, in framing the expression of the dental formula. In fact, till the appearance of Professor Owen's Odontography, the normal division and theoretical signification of the different molar teeth in these genera were not understood.[1]

In the ordinary Pachydermata, which the Rhinoceros may be supposed to represent, there are normally four milk or deciduous molars in both jaws, the hindmost of which has the complicated form which characterizes the last true molar of the adult animal. They are frequently reduced to three in other genera, by the suppression of the anterior tooth, which is the most variable and rudimentary in form. These teeth are succeeded vertically by an equal number of premolars, the last of which is always of a simpler form than the tooth of which it takes the place ; and they, in like manner, are subject to a numerical reduction by the non-development of one or more of the anterior teeth. Behind the premolars are the true molars, the normal and developed number of which is invariably three, this set being exempt from the partial suppression to which the others are subject. They are distinguished from the premolars by greater complexity of form ; they come into place like the milk molars, in antero-posterior succession, and the first of the series is protruded and in use before the appearance of the last premolar, which immediately precedes it in position in the jaw. In the adult animal, in most genera, the whole of the premolars and true molars are simultaneously present and in use in the jaws. A remarkable exception from this rule takes place in the subgenus of the hog tribe, called *Phacochœrus*, in which, in consequence of the complicated form and large size of the last true molars, there is not room in the jaws to accommodate the whole number at one time, and the first true molar is worn down and pressed out before the last molar is protruded. This last molar is gradually pushed forward, causing the anterior teeth to be shed, so that the number of molar teeth in the upper jaw, which at one time in the adolescent animal amounts to five on each side, is finally reduced to one or two in the advanced age.[1] Precisely analogous conditions take place in the true Elephants, in which this kind of exception from the ordinary mode of dental succession is carried to the greatest known excess.

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[1] *Ante*, p. 11.

Dinotherium.—The first and most simple deviation from the usual Pachydermatous type, in the dentition of the Proboscidea, is presented by *Dinotherium.* In this genus, only two milk molars, viz., the penultimate and last, have been met with in both jaws, one or two of the anterior teeth of this set being suppressed. The last milk molar, above and below, is three-ridged, while the penultimate has only two ridges. These teeth are replaced vertically by an equal number of premolars, which represent the penultimate and last, the two anterior teeth of this series being also suppressed. The last premolar, as well as the penultimate, is only two-ridged, conforming to the ordinary rule of being simpler in form than the milk molar which it succeeds. Of the three true molars, the first or antepenultimate, in both jaws, is three-ridged, repeating the complex form of the last milk molar, while the penultimate and last are only two-ridged. This is a very remarkable anomaly, of which no other example is known among the Pachydermata, as it is commonly the last true molar which reiterates the form of the last milk molar. The first true molar is protruded and in use before the last milk molar is shed, so that in the adolescent animal there are two contiguous teeth, which have each three ridges. We have, in this circumstance, the first essential proboscidean character, which at once distinguishes *Dinotherium* from the Tapirs and allied genera, and indicates its near relations to *Mastodon.*

In regard to the number of teeth which are in place and in use at the same time, *Dinotherium* is less aberrant than even *Phacochœrus,* as the two premolars and three true molars in the adult animal are simultaneously present in both jaws. The molar formula *Dinotherium* is therefore 2 premol. + 3 mol. = 5 in each side of both jaws; and the number of ridges in the different teeth, according to their successive position in the jaw, is 2 + 3 in the milk molars; 2 + 2 in the premolars, and 3+2+2 in the true molars.

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[1] Owen, Odontography, p. 550.

Mastodon. Sect. Trilophodon.—*M. Ohioticus.*—The next degree of deviation from the ordinary dental rule is presented by *Mastodon Ohioticus.* In this species, which appears to be the most nearly allied of the well-known forms to *Dinotherium*, there are three deciduous molars in both jaws, the most anterior of the series being suppressed. Of these, the antepenultimate, or anterior tooth (being theoretically the second) in the upper jaw, measures 1.4 inches in length, by about 1.4 in width; and the penultimate, or second (theoretically the third), measures 1.7 by 1.75 inches. These teeth are of the same form, each consisting of four points, which are disposed in two transverse ridges; and they further correspond with the same teeth in the ordinary Pachydermata by differing but slightly in relative size. The third milk molar, as in *Dinotherium*, consists of three transverse ridges, each composed of two pair of confluent points. It measures three inches in length, by 2.4 in width. The milk molars of the lower jaw differ in no important respect from those of the upper, except in being narrower in proportion to their length: and in the greater development of the anterior and posterior subordinate talon ridges.

With respect to the premolars, the statements which have been advanced regarding them are conflicting. They have never been observed in either of the jaws by Godman, Hays, Cooper, Harlan, or any other of the American Naturalists who have described the dentition of *M. Ohioticus;* nor has their presence been noticed by Dr. Grant. But Professor Owen, in his British Fossil Mammalia, affirms that they have been recognised in this species; and, in his Odontography,[1] he figures and describes a tooth as the penultimate premolar of the upper jaw. It is there stated to be composed of two bifid transverse ridges, girt by a basal cingulum, and to be of a simpler form than the second deciduous molar; the crown being broader in proportion to its length, and measuring one inch five lines, by one inch four lines.

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[1] *Loc. cit.* p. 260. Pl. 144, fig. 3, *p.* 1.

Professor Owen also gives a figure of the hypothetical position of the same tooth in the lower jaw,[1] the presence of which he admits has not yet been established in the species. The accurate determination of this point is of considerable systematic importance, as the occurrence of this premolar constitutes one of the two characters upon which (failing those advanced by Cuvier) Professor Owen founds his generic distinction between *Mastodon* and *Elephas*. Had the tooth been observed *in situ* in the jaw as in the Dax Specimen of *M. angustidens*, figured by Cuvier and in the specimen of *M. longirostris*, figured by Kaup, its occasional presence in the upper jaw of *M. Ohioticus* would have been placed beyond doubt; but the tooth described by Professor Owen appears to have been a detached specimen, and no characters are attributed to it inconsistent with its being the first milk molar of the upper jaw. In order to arrive at a certain determination of the point, we have been permitted to make a section of a specimen consisting of the entire palate, of a young *Mastodon Ohioticus* in the British Museum, containing the second and third milk molars, with the first true molar protruded, and the second true molar in germ. A section was made both along the palate, and along the outside of the jaw; but not a trace of a premolar was visible, although the cranium was exactly of the age when a premolar, if developed, ought to have been shown. A similar negative result attended a corresponding section of a specimen of the same age of the lower jaw. The only other evidence which could establish the case would be the finding of an unworn tooth in front of the third milk molar. But, so far as we are aware, no instance of this sort has been recorded, notwithstanding the great number of young specimens which have been described by different observers; and the result of the whole evidence at present is, that, ordinarily, the premolars are entirely suppressed in *M. Ohioticus*, in both jaws.

There is nothing, therefore, in the mode of succession of the teeth in this species, to show where the deciduous series terminates and the true molars begin. The last milk molar is followed in antero-posterior succession, as in *Dinotherium*, by a tooth which has its crown divided also into three ridges, and is thus indicated to be the antepenultimate, or first true molar. It measures four inches long, by about three in width, differing only in size from the tooth which precedes it. The penultimate, or second true molar (being the fifth in the order of succession), consists, also, of three ridges, and measures about five inches by three and a half. The third, or last true molar, consists of four principal ridges, and a small heel ridge, which varies considerably in amount of development. This tooth measures 7.25 inches or upwards, by about 4.5 in width.

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[1] *Ibid.* Pl. 144, fig. 7, *p*. 1.

The inferior true molars in *M. Ohioticus*, agree with the upper in the form and division of their crowns, except the last which has usually five principal ridges. They are narrower in proportion to their length, and the subordinate talon ridges are more developed. The molar formula in this species is, therefore, 3 milk molars in the young animal; and 0 premol. + 3 premol. = 3 in each side of both jaws of the adult; the number of ridges in the different teeth according to their succession being $\frac{2+2+3}{2+2+3}$ in the milk molars, and $\frac{3+3+4}{3+3+5}$ in the true molars. With regard to the number of teeth which are simultaneously present in the jaw; the lower jaw of *Tetracaulodon* figured by Godman,[1] shows the three milk molars in use, and the first true molar in its alveolus, there being four out of the whole number of six teeth at one time in the jaw. These are ultimately in advanced age reduced to the last tooth, the others being shed.

M. angustidens. — The dentition of *M. angustidens* is involved in great confusion, in consequence of most authors, who have written on this species, having mixed up, under this name, two distinct forms, the one characterized like *M. Ohioticus*, by a *ternary*, the other, by a *quaternary* division in the ridges of the middle teeth. It will be necessary to enter at some length upon the evidence on this point, more especially, as the two latest authorities of weight, Prof. Owen and M. de Blainville do not admit a specific difference between *M. angustidens*, and *M. longirostris*. On the other hand Dr. Kaup has, in some instances (as in the case of the Stellenhoff lower jaw found near Vienna,[1]) excluded from his *M. longirostris*, specimens which assuredly belong to it; while in others (viz. the Georgensmünd Mastodon teeth described by von Meyer) he has transferred to this species, molars which appear to pertain to *M. angustidens*.

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[1] Amer. Phil. Trans., New. Series, vol. iii. pl. xviii.

The first point to determine, under these circumstances, is the form to which the specific name of *M. angustidens* is properly applicable. Cuvier's description of the species commences with the Simorre tooth (Oss. fossil. tom. i. p. 255, Divers Mastodontes, pl. 1. fig. 4) which has the crown divided into three ridges, with a back talon of two tubercles, measuring 4.5 inches in length by 2.35 in width. The next specimen which he describes as belonging to it, is the Dax fragment (pl. 3. fig. 2.) containing two teeth implanted in the palate on one side, the anterior of which is the unworn germ of a premolar, and the posterior, nearly of the same size as the Simorre tooth, like it consists of three ridges and a small talon of two tubercles. A third tooth which he immediately afterwards attributes to this species, is another Simorre specimen (pl. 3. fig. 3.) measuring 3.6 inches by 2.6, and having its crown also divided into three ridges. It is therefore to a species having the intermediate molars distinguished by a ternary division of the crown, as in *M. Ohioticus*, that the specific name of *M. angustidens* is strictly applicable, so far as priority of description, and reference to original types can be taken as the guides to a decision on the point.

Of the other specimens referred by Cuvier to his *M. angustidens*, and represented in the four plates devoted to 'Divers Mastodontes,' the South American teeth (figs. 6 and 7 of pl. 1, and fig. 4 of pl. 3) appear to belong to *M. Andium*, as has been advanced by M. de Blainville, and nearly all the rest, which are susceptible of determination, belong to *M. Arvernensis* (M. longirostris of

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[1] Cuv. Oss. Foss. edit. 1834, tom. ii. p. 363. pl. 2, figs. 4 and 5.

Kaup), with the exception of figs. 1 and 2, of pl. 1. fig. 11, of pl. 2. and fig. 14, of pl. 3., which are probably to be referred to *M. angustidens.*

We have already stated the grounds (ante p. 21,) upon which von Meyer, following up the observations of Croizet and Jobert, distinguished *M. Arvernensis* from *M. angustidens,* and that Kaup was led by his researches to the same conclusion. It would appear, from a communication in Bronn's Lethæa, that the ridge formula which Kaup attributed with doubt, to *M. angustidens* is $\frac{2+?+3?}{?+3+3}$ in the deciduous series, and $\frac{3?+4+5}{3?+4+4}$ in the true molars.[1]

M. de Blainville has entered at great length, in his Ostéographie, on what had been previously written regarding *M. angustidens,* and he has given a beautiful series of illustrations of all the teeth in succession, in both jaws, as he conceives them to be developed in this species. The rich collection of specimens, discovered by M. Lartet, and others, in Gascony and along the flanks of the Pyrenees (a large portion of which is displayed in the palæontological gallery of the Paris Museum) furnishes ample materials for establishing the specific independence of *M. angustidens* and *M. longirostris.* But M. de Blainville has not attached sufficient importance to the constancy of the ridge formula: he has throughout his illustrations intercalated Eppelsheim teeth of the latter species, having four ridges, with Gascon specimens of the former, having three ridges. In consequence, the teeth of the two species are not merely intermixed, but a wrong position in the jaw is in many instances assigned to M. Lartet's specimens of the true *M. angustidens.* This remark applies, without exception, to the determinations of the two last teeth of the upper jaw. Giving a numerical expression to M. de Blainville's descriptions of the different teeth, the ridge formula in *M. angustidens* would be $\frac{2+3+4}{2+2+3}$, $\frac{3+4+5}{3+4+6}$, respectively, in the three deciduous, and three true molars, on each side of both jaws. It is apparent that the lower numbers do not coincide with the upper, and that, followed in sequence, they deviate widely from the uniform succession of three ridges presented by the last deciduous, and the first and second true molars in *M. Ohioticus*.

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[1] Lethæa Geognost. p. 1239.

Professor Owen has on two occasions described, in detail, the dentition of *M. angustidens*, and the result stated in his 'Odontography' is, that he has seen as yet no evidence that the teeth described by Cuvier and by Kaup characterize different species. In his 'British Fossil Mammalia,' he identifies English specimens with some of the typical forms figured by Cuvier, and the number of ridges which he assigns to the different teeth, according to their succession, is $2+3+3$ to the deciduous molars, 2 to the small premolar, and $3+4+5$ to the true molars.[1] This formula is liable to the same objections as that put forward by M. de Blainville. In his 'Odontography,' however, published subsequently, Professor Owen describes the teeth of *M. angustidens* in a different manner, and the number of ridges assigned by him to the successive molars in the upper and lower jaws may be expressed thus: $\frac{2+3+4}{2+3+4}$, in the deciduous molars, and $\frac{4+4+5}{4+4+5}$, in the true molars.[2] This formula, with the exception of the number attributed to the last milk molar of the lower jaw, is precisely the same as that assigned by Dr. Kaup, to his *M. longirostris*, Professor Owen having referred, in almost every instance, on this occasion, to Kaup's figures, which he quotes as the types of his descriptions. But he still alludes to Cuvier's Dax specimen of *M. angustidens*, as identical with Kaup's species, although it is represented in the original figure, and described by Cuvier, as three ridged; and he states in the 'British Fossil Mammalia,' that, the rich series of analogical facts in the dentition of *M. giganteus* (*M. Ohioticus*), would "now appear to complete the demonstration of the specific identity of the *Mastodon longirostris*, and *Mastodon angustidens*," (p. 290).

From these details it will be seen how various and opposed the opinions of the best authorities are, up to the present time, regarding *Mastodon angustidens*. In consequence of its rarer occurrence in the fossil state, the available materials for tracing the dentition of this species are less numerous and complete than in the case of *M. Ohioticus.* The following descriptions are chiefly derived from specimens in the Paris Museum, the most of which have been figured by M. de Blainville.[1] Of the milk or deciduous molars in the upper jaw, the third only has yet been met with, *in situ,* in the palate. It is well shown, on the right side, in the posterior tooth of the Dax specimen figured by Cuvier (Oss. Foss. pl. 3. fig. 2.), and referred to above, the crown consisting of three transverse ridges, and an accessory talon of two tubercles, each of the ridges being composed of two pairs of confluent mammillæ. A single tubercle juts out into each of the hollows between the ridges alternately with the principal points, causing the trefoil-shaped discs, which the worn teeth present in this species, so different from the lozenge-shaped discs of *M. Ohioticus.* The dimensions of this tooth are not mentioned by Cuvier, but it may be gathered from the context of his description, that it measured a little above three inches long by about two in width. The same tooth, of the left side of the upper jaw, is seen in a most instructive specimen found by M. Lartet, near Sansans, in the department of Gers, containing two molars *in situ,* both of which are three-ridged. Of these the anterior, which is the third milk molar corresponding with the Dax tooth, is in an advanced stage of wear, the ridges of the crown being ground down into three disc surfaces. No back talon is distinguishable ; if originally present, it has merged into the wear of the last ridge. This tooth measures 3.15 inches long, by two of width in front, and 1.75 behind, narrowing a little towards the posterior end. It is figured by M. de Blainville.[2] The same collection possesses another detached specimen from M. Lartet, of exactly the same size, but less worn, which shows three distinct ridges, and a small subordinate talon. The grinder described and figured by von Meyer, in his memoir on the fossil remains of Georgensmünd (p. 38, tab. 2. fig. 7.)

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[1] 'British Foss. Mammalia,' p. 286.

[2] 'Odontography,' p. 619—23.

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[1] One of the authors, during a visit to Paris, had the freest access to these specimens, by the liberal permission of MM. de Blainville and Laurillard. H. F.

[2] Ostéographie, pl. xv. fig. 3*c* sup.

appears to furnish another example of the third milk molar of the upper jaw, left side, of this species. The crown is divided into three ridges, with a small posterior talon. It corresponds closely to the Gers specimens in dimensions, being three inches long by two in width. Von Meyer describes this tooth as the second milk molar of *M. angustidens*, but the size would seem to be conclusive against the correctness of this determination. Kaup compares it to the third upper molar of his *M. longirostris.* (Oss. Foss. de Darmst. p. 81.)

With regard to the first and second upper milk molars, neither of these teeth having yet been observed *in situ* in the jaw, we are unable to refer with confidence to any specimens for their characters. But we are inclined to regard the tooth described by von Meyer (Georgens. p. 38, tab 1, fig. 4), as representing the penultimate or second, and fig. 2 of the same plate as the first. The former measures 2.2 inches by 1.4, and is composed of three ridges, which are so far advanced in wear as to furnish no good diagnostic characters. Von Meyer refers it with doubt to the last milk molar of the lower jaw, while Kaup considers it to be the second upper of the left side of his *M. longirostris.*[1] The specimen (fig. 2 of von Meyer's plate) here regarded as the antepenultimate or first milk molar, has a square crown composed of four points. It measures 1.6 inches in length by 1.4 in width, resembling closely in form and dimensions the small Simorre specimen figured by Cuvier (Diver. Mast. pl. 1, fig. 2), which is also about 1.6 in. long by 1.4 wide, and is regarded by M. de Blainville as the first upper molar of *M. angustidens.* This eminent palæontologist assigns the same place to several other specimens from M. Lartet and others; but such of these figures as are susceptible of exact determination, from their being found *in situ* in the jaw, are derived from Auvergne and Eppelsheim specimens of *M. longirostris.* The same remark applies to M. de Blainville's figures and descriptions of the second milk molar in both jaws.

Of the inferior milk molars, the two anterior, like the upper, have not yet been found *in situ*, and the specimens which have been assigned to them are, in consequence, in a great measure conjectural determinations. The first was probably a simple tooth consisting of a pair of cusps; and the second, reasoning from the analogy of the same tooth in the nearly-allied *M. Andium*, was probably three ridged. The third is represented by the 'dent de Saxe' (Oss. Foss. pl. 2. fig. 2.), upon which Cuvier founded his nominal species of *M. Minutus*, but which M. de Blainville, with reason, attributes to *M. angustidens*. It is of the left side of the lower jaw; the crown is divided into three ridges, each composed of two pairs of confluent points, with a well-developed back talon of two tubercles, and one or two subordinate tubercles in the spaces between the ridges. The dimensions of this specimen are 3.25 inches long, by 1.25 of width in front, and 1.65 behind. An unworn germ, of unknown origin, in the British Musuem, of the same size as the Saxon tooth, and exactly resembling it in the ternary division and form of the crown ridges, furnishes another example of the third inferior molar. M. de Blainville (loc. cit. pl. 15. fig. 3 *b*,) attributes the same place to a worn three-ridged tooth, from the collection of M. Lartet, found near Sansans.

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[1] Oss. Foss. de Darmst. Pt. iv. p. 73.

We have seen that the premolars, of which two are developed in *Dinotherium*, appear to be entirely suppressed in *M. Ohioticus*. But there is no doubt about the presence of one in the upper jaw of *M. angustidens*. A beautiful illustration of this tooth is furnished by the Dax specimen, previously referred to. As figured in the 'Ossemens Fossiles,' (pl. 3. fig. 2 *a b*) it is shewn as a germ of a square form and composed of four points. It is proved to be a premolar, and to be protruded vertically in the ordinary manner, by being unworn, while the third milk molar behind it has the three ridges well affected by wear. This circumstance is clearly indicated by Cuvier in his description of the specimen.[1] Von Meyer refers to the same tooth, the Georgensmünd specimen represented in tab. 1. fig. 1. of his Memoir, which resembles the Dax specimen in form, and in the crown being composed of four points; it measures about 1.6 inches square.

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[1] Ossemens Fossiles, tom. i. p. 256.

This upper premolar, as has been pointed out by Professor Owen, takes the place of the second milk molar; it therefore represents the penultimate of this series. There is no evidence that the third milk molar of the upper jaw in this species is followed by a corresponding vertical successor. It is of importance to observe this apparent irregularity in the order of suppression. In *Dinotherium,* the two last premolars are developed, the two anterior being suppressed; in *M. Ohioticus* the whole four remain undeveloped; while in *M. angustidens,* the penultimate alone is developed, the two anterior and the last being suppressed. A similar order of suppression has been observed in the premolars of *M. longirostris*

In regard to the lower jaw, there is no evidence yet that a premolar is included in the dental succession of the inferior grinders. Von Meyer, with doubt, assigns this place to a detached tooth which he figures (*loc. cit.* tab. 1. fig. 2.), but the determination is merely conjectural, Kaup referring it to his *M. longirostris;* and it is by no means certain that this specimen does not belong to the upper, rather than to the lower jaw. That a rudimentary lower premolar may have been developed in this species is highly probable; but we are not warranted, in the absence of direct proof, to hazard any inference respecting organs, which are liable to be entirely suppressed, and which, when developed, are so rudimentary in form as not to be of functional importance in this tribe of animals.

The materials to illustrate the dentition of the adult animal have been found in sufficient abundance to leave no room for doubt respecting the characters and succession of the true molars. The antepenultimate, or first,[1] is seen in the Sansans specimen from M. Lartet, *in situ* in the left side of the upper jaw along with the third milk molar, which we have described. It is an oblong tooth, in the condition of an almost unworn germ, having the crown divided into three distinct ridges, with a well-marked basal cingulum on the inside, and a small back talon. It measures 4.13 inches in length by 2.75 of width in front, and 2.25 behind.

Another example of this tooth appears to be furnished. by fig. 5, of tab. 1. of von Meyer's memoir. The crown has the same three-ridged form as the Sansans specimen, with which it agrees very closely in dimensions, being 4.2 inches long, by 2.7 in width. Von Meyer refers it with doubt to the third molar of the lower jaw, right side of this species, while Kaup assigns to it the same position in the lower jaw of his *M. longirostris* (*loc. cit.* p. 81).

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[1] De Blainville, Ostéographie, pl. 15. fig. 4.

The penultimate, or second true molar, is shown *in situ* along with the last, in another instructive Gascon specimen from M. Lartet, displayed in the Paris Museum. This fragment, likewise, is of the left side of the upper jaw. Of the two teeth which it contains, the anterior (or penultimate) had been a long time in use, and is very much worn. It is nearly rectangular in form, and the crown is distinctly divided into three discs, which indicate the same number of ridges. No back 'talon' is distinguishable, the abrasion of the last ridge being far advanced. The dimensions of this tooth are 4.5 inches long by 2.75 of width in front, and 2.6 behind. It is described by M. de Blainville as the fourth, or ante-penultimate.[1] The posterior tooth in this specimen, being the third, or last true molar, like its equivalent in *M. Ohioticus*, is more complicated in form than the two which immediately precede it. The crown consists of four ridges, each composed of two pairs of confluent points, arranged somewhat alternately, and there is no distinct heel ridge appended to the posterior extremity. This tooth is wide in front, and contracts very considerably backwards, a character common in most species of Mastodon, to the last molar of the upper jaw. The dimensions are,—length 6.25 in.; width in front, 3.25; width behind, 2.25. The palæontological gallery of the Paris Museum contains numerous other specimens of the last upper molar of *M. angustidens*, four of which, from different localities, have been admirably figured[2] in the 'Ostéographie.' They all agree in having the crown invariably divided into four ridges; the only variety which they present being in the greater or less development of the 'talon' appendage of the last ridge. Of these, the superb Tournans specimen,[3] which comprises

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[1] De Blainville, *loc. cit.* p. 296, pl. 15. fig. 4 *b* sup.

[2] *Ibid.* fig. 5 *a*, *b*, *c*, *d*, sup.

[3] Ibid. pl. 14.

PART II.

Containing the Continuation of the PROBOSCIDEA, will be Published shortly.